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## DEDICATION

China, with its long history and rich culture, has special meaning to all humanity. Over the past 100 years, the rest of the world has watched the sometimes magnificent and sometimes terrifying political, social, and economic changes sweep across this huge country. Wildlife and natural environments suffered from many of these changes. By 1965, at the beginning of the Cultural Revolution, this third largest country in the world had only 19 nature reserves, and some of them were badly damaged in the following decade.

Since 1976, however, China has made extraordinary progress for conservation. Scientists conducted surveys throughout this varied land, and found that a wealth of wildlife, including cranes, survived. The government has moved quickly to safeguard these resources. By the time of the International Crane Workshop, in early 1987, China had well over 300 nature reserves covering over 19,000,000 hectares. The process has continued, and by the year 2000, 500 reserves should form one of the largest and most significant reserve systems in the world.

This proceedings is dedicated to our Chinese colleagues — scientists, conservationists, government officials — who have worked with dedication, courage, humor, and creativity to meet the immense challenges to conservation in this most populous of all nations. Their work is an inspiration to all of us who care about cranes and other wildlife. We wish them the best of success in the coming decades, and hope that the international community can do its share in assisting their great labors on behalf of cranes.



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## WELCOMING MESSAGE

Greetings from China! You can see for yourselves that we have friends all over the world.

China is the only country in the world with sizeable portions of Palearctic and Oriental realms. That is why China has so many species of birds, 1,186 up to 1982. The ornithological work of China at present may be presented under three topics.

### I. Studies of special groups of rare and precious birds.

(1) Cranes — There are 15 species in the world, of which 9 have been recorded in China. For this workshop, I have been informed that we have so far received 112 papers from Chinese delegates and 37 from foreign delegates, totalling about 150. The workshop organizers will publish our proceedings later on. The crane experts have carried out field work with all the crane species found in China, with emphasis on breeding and wintering ecology, relative abundance as well as captive management.

(2) Waterfowl and ibises — Our Ministry of Forestry and the other relevant organizations have been carrying out survey work of wetlands, which provide appropriate habitats for waterfowl and waders. As you may know, the crested ibis *Nipponia nippon*, now nearly extinct in Japan, has been re-discovered in Shaanxi Province, China. Funds are now being made available for work on this species in the zoo and also in the field.

(3) Pheasants and grouse — There are quite a number of Chinese research workers engaged in the studies of endemic as well as endangered species of Chinese pheasants and grouse. Results obtained to date include: breeding ecology studies of cared pheasants *Crossoptilon*, monal pheasants *Lophophorus*, long-tailed pheasants *Syrmaticus*, and hazel grouse *Tetrastes sewerzovi*; distributional ranges and censuses of populations; investigation of acoustics, chromosomal patterns and phylogenetic relationships; and captive breeding of *Crossoptilon*, *Tragopan*, and *Lophophorus*.

### II. Faunistic Work

The Chinese Academy of Sciences has organized multi-discipline scientific exploration-teams to work on the Qinghai-Xizang (Tibet) Plateau for more than 15 years. An international symposium was held in Beijing in 1980, and a monograph consisting of two volumes, entitled *Geological and Ecological Studies of the Qinghai-Xizang Plateau* has been published.

During recent years, studies of local or provincial avifauna of southern Xinjiang, Sichuan, Hainan Island, Guizhou Province, the Ever-white Mountains of Jilin Province, the Qinling Range of Shaanxi Province, and Gaoligong Mountain of Yunnan Province have been published.

During the 1960s, we published a large volume on China's economic avifauna, which was considered sufficiently important by the Americans to be translated into English by the U.S. Department of Commerce. We have now been working on *Fauna Sinica*, a serial publication consisting of 14 volumes. Up to the end of 1986, four volumes have been published, with two other volumes still in press. I have recently written in English *A Synopsis of the Avifauna of China*, and also with collaboration of an artist, *Pictorial Handbook of the Chinese Birds*, both of which will be published before long.

### III. Bird Banding

The Ministry of Forestry has recently organized a National Bird Banding Center in Beijing. Ringing of birds started up at 50 different localities in 1985. There are also people in different institutions who have been cooperating with foreign institutions in the work.

I have no time now to cover bird conservation and nature reserves in China . . . just a few words concerning the ornithological society and publication of ornithological papers. The China Ornithological Society was founded in 1980 with about 300 members. In November, 1985, I was elevated to President Emeritus and Qian Yanwen was elected as the new President. Owing to the lack of funds, we have not yet published an ornithological journal. Most of our technical papers have appeared in *Acta Zoologica Sinica*, *Acta Zootaxonomica*, and *Zoological Research*. Semi-popular articles are dealt with in *Chinese Wildlife* or in the *Journal of Zoology*. All technical papers are required to have abstracts in English, while the semi-popular papers only have titles in English.

Owing to hearing problems, I will not be able to go with you to Qiqihar, but I would like to send my best wishes to all the participants and for the success of the International Crane Workshop.

I am especially pleased to welcome Dr. George Archibald of the International Crane Foundation (ICF) who has inspired crane research not only in China but also in other countries all over the world. I only feel regretful that Dr. Ron Sauey, co-founder of ICF, has passed away at a time when he is so much needed in crane work everywhere.

May 1987

Professor Cheng Tso-hsin  
Institute of Zoology  
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Beijing, China

## OPENING ADDRESS

“Keep It Positive”

Qing Li Sheng, Chen Lei, Wang Lian Zheng, Qing Jian Hua, Kong Fu Kui and members of the Chinese Association for Wildlife Conservation and our hosts in Heilongjiang, thank you very much for inviting us to attend the International Crane Workshop in Qiqihar. Qiqihar is a uniquely appropriate place to meet because it is a crossroads for cranes of the arctic, grassland, and boreal zones.

Let me introduce the foreign guests by their nations . . .

China is perhaps the most important country in the world for cranes. Eight of earth's 15 species of cranes are native to China, and this wide land provides critical habitats for the majority of four endangered species: the black-necked cranes, red-crowned cranes, white-naped cranes and the Siberian cranes. The International Crane Foundation had its beginning in Wisconsin, USA, in 1972. At that time, China was in the throes of the Cultural Revolution. During the 1970s we wrote many letters to China seeking information on the welfare of the cranes. China's foremost ornithologist, Professor Cheng Tso-hsin, would respond that such and such species was found in China but that little information was available on the status of the wild cranes. China was then closed to the outside world, and during those difficult years most Chinese scientists were unable to study birds.

Times have changed.

During the past eight years, I have been both delighted and astonished by the progress that China has made in the study and conservation of cranes. The protection of the impressive Zhalong Marsh, and the facilities at the headquarters of the reserve are testimony to the conservation commitment of the Chinese government. Moreover, there are 14 other nature reserves that protect about 1/2 million hectares of critical habitat for cranes and other waterfowl throughout China. This week, at this historic meeting, for the first time, crane researchers from throughout China share their discoveries with the outside world.

China is rapidly modernizing. Economic progress is evident everywhere. Progress in rural areas now places new strains on the resources within the nature reserves. At Zhalong, for example, increased fishing in summer and reed-cutting in winter are undoubtedly affecting the wildlife community in this remarkable ecosystem important to six species of cranes.

As human numbers soar, earth's delicate wetlands are increasingly endangered. Their survival now depends on reaching an accommodation with humanity. It is man's responsibility to develop successful formulae for that delicate interaction. Finding such solutions is the most important mission of this International Crane Workshop.

During the next five days, we have a unique opportunity to get to know each other, to learn from each other, and to develop plans for international cooperation. In this way, not only can we help the cranes, but the cranes can bring people from different countries together in programs of long-term interaction. Today we have that chance, as over 200 delegates from 29 nations gather near the cranes at China's earliest protected area for cranes.

Professor Cheng is a great optimist. He has a wonderful expression “K.I.P. — Keep It Positive.” His attitude has found fulfillment with the recent discoveries of cranes in China and the protection of their habitats. Let us make “K.I.P.” the theme of the 1987 International Crane Workshop as cooperatively, in the spirit of Professor Cheng, we seek to find that balance between the survival of cranes and the welfare of humanity.

Finally, may I thank our Chinese hosts for their splendid arrangements to make this workshop both pleasurable and productive.

May 1987

George Archibald  
International Crane Foundation  
Baraboo, Wisconsin USA



## INTRODUCTION

Exactly four and a half years ago, delegates were assembling for the International Crane Workshop at Qiqihar, China. On this date, 1 May 1987, the cranes were moving north across northeast China, as they had done for millennia. Six species pass close by Qiqihar, a city of over a million people in Heilongjiang Province and aptly known throughout China as "Crane City." Zhalong Nature Reserve lies just 35 km outside the city. Here, the endangered red-crowned cranes were incubating eggs in early May, and the endangered white-naped cranes looked for nest sites. On drier ground, demoiselle cranes guarded their territories. Flocks of hooded and Siberian cranes paused to feed and rest on their long migration. Among them strode common cranes, probably all migrants although the year before a pair had nested at Zhalong.

Our workshop was co-sponsored by the International Crane Foundation and the Chinese Wildlife Conservation Association, an organization administered by the Ministry of Forestry, Beijing. Most of the foreigners arrived in Beijing on April 30 or May 1 for our first view of China. Beijing was in the full bloom of spring, and we wandered about unable to read the street signs and dazed by jet lag and awkward airline connections; also the beauty and scale of this city dazzled us. On May 2, we boarded the train for a 24-hour journey to Qiqihar, a welcome chance to rest, to look out the window at the ever-varying landscape of villages, farms, and occasional wetlands with waterfowl and black-winged stilts. We talked and got to know each other, Americans and Vietnamese and Iranians, Indians and Pakistanis, Chinese and Soviets, Kenyans and Zambians.

Upon arrival at Qiqihar, buses carried us out to the headquarters of Zhalong Nature Reserve. From the high roof top of the education building, we had a sweeping view of the endless marsh. The landscape was brown, for ice had just recently left the shallow waters and the new growth of reeds had hardly begun. Because villagers had cut the old growth of reeds during winter, we could easily watch the red-crowned and white-naped cranes on their territories. China, with eight species of cranes, is certainly the most important country on earth for cranes.

From our lookout, we could also see villages in the near and far distance. People live on high ground in the marsh, and depend on the marsh for food and income. The mixture of people and wildlife, and the balancing of their needs even on nature reserves, was perhaps the most important theme for this international meeting. The success, or failure, of integrating economic development with wildlife conservation would determine the future for cranes in China and most other countries.

Following the opening ceremony for the workshop, we returned to Qiqihar, to the newly remodeled Crane City Hotel. Here we held our meetings over the next five days. In total, 225 scientists and conservationists participated in the meetings, coming from 28 countries. We listened to over 100 papers.

This proceedings contains 70 papers, 34 from China and the remainder with authors from 17 countries. All but four of these papers were presented at Qiqihar. Two papers by authors unable to attend the workshop — one on demoiselle cranes in the Ukraine and the other on wattled cranes in South Africa — are included, as well as a report prepared at ICF's request on Siberian cranes at Lindian, on the east side of Zhalong Marsh. Finally, I have included a paper on cryopreservation of crane semen which was presented at the 1983 International Crane Workshop in India but mistakenly left out of that proceedings.

This volume has special interest because of its breadth of information on cranes, wetlands, and conservation in China. Until the time of the 1987 workshop, such information was simply unavailable. The Chinese papers are presented in Part 1, and readers should refer to Figure 1 on page 6 for locations covered by the papers. This proceedings also contains abstracts from another 19 papers by Chinese authors. Some of these papers appear in the Chinese version to these proceedings, published in Beijing in 1990 by the Forestry Publishing House of China, and a few have been published elsewhere in China. In addition, 25 resolutions passed by workshop delegates appear in this volume. These resolutions express the special concerns of the delegates regarding issues of importance for cranes and wetlands, and were sent to the relevant governments after the workshop.

Our crane workshop in Qiqihar also provided the chance for discussions on the eastern white stork *Ciconia boyciana*. The stork papers are just now being published in a separate volume: Coulter, M.C., Wang Q., and C.S. Luthin. 1991. Biology and conservation of the oriental white stork *Ciconia boyciana*. Savannah River Ecology Laboratory, Aiken, South Carolina USA. 244 pp. Copies are available from The Savannah River Ecology Laboratory, Drawer E, Aiken, South Carolina 29802, U.S.A. and The International Waterfowl and Wetlands Research Bureau, Slimbridge, Gloucester GL2 7BX, England.

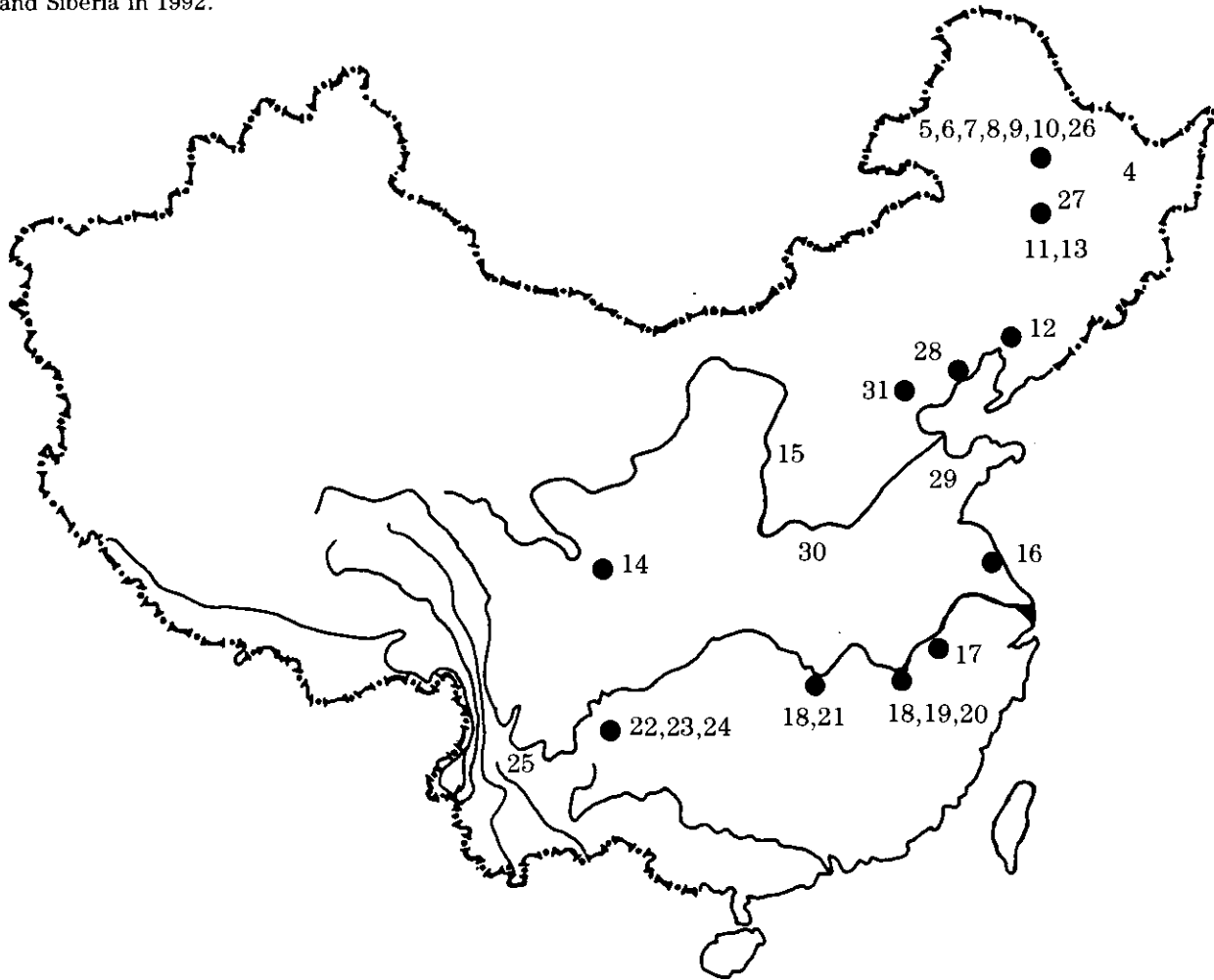
International workshops convene to share information on past research; but at least as importantly, the workshops give conservationists from distant places the chance to meet and plan work for the future. The 1987 meeting has had many results.

Most dramatic have been the achievements of international cooperation involving delegates who met at Qiqihar. In 1987-88, researchers from Japan, Korea, and China held cooperative counts of red-crowned, white-naped and hooded cranes through much of their wintering range — an important event because winter counts provide the best measure of populations of these magnificent and endangered species. Crane banding has achieved much since 1987, including cooperative crane banding projects involving Japanese-Soviet, Japanese-Chinese, and Chinese-Soviet handlers.

After dinner one evening in Qiqihar, the Indian delegates had the idea of convening a crane workshop for central Asian cranes in Gujarat, India. This discussion was the beginning of the 1989 Asian Crane Congress, held in Rajkot, India with

attendance by both Chinese and Soviet researchers. Less than a month later, a workshop on sarus crane and wetland conservation convened in Vietnam, at the crane reserve first announced to the world at Qiqihar in 1987; delegates from 13 countries attended, representing most of the south Asian nations with sarus cranes.

One of the disappointments of the Qiqihar meeting was the sparse representation from the Soviet Union. Although China and the Soviet Union share six species of cranes migrating across their borders, and many researchers on both sides of the border work on the same problems, little interaction had previously been possible between crane workers of the two countries. Several leading Soviet ornithologists wished to attend the Qiqihar meeting, but in the end, only one appeared. Nevertheless, he in turn organized a 1989 regional crane meeting in Estonia attended by four of the Chinese he met in Qiqihar. Cooperation has continued to grow, with a meeting held in the Soviet Union on the border with Mongolia and China in 1991 and a larger meeting planned for the Amur River region, on the border between Heilongjiang Province and Siberia in 1992.



**Figure 1.** Locations for crane papers from China. Numbers refer to the listing in the Table of Contents.

Within China, great progress for the cranes has continued, sometimes in cooperation with foreign workers first contacted at Qiqihar in 1987. Of many achievements, some of the most notable have been the surveys of black-necked cranes in Tibet, Sichuan, and Yunnan (far more birds exist than previously thought), the studies and protection of a migration stopover for cranes by the mouth of the Yellow River in Shandong, the discovery of wintering Hooded Cranes in Hubei, development of reserves in Yunnan Province and Inner Mongolia, and the beginning of active resource management programs at East Dongting, Cao Hai and other nature reserves.

Conservation gains in China could still easily be lost. Nature reserve managers must learn how to channel human activities in and around nature reserves toward sustainable resource use that ensures long-term benefits to people and a secure home for cranes. While some reserves are making progress, none have achieved adequate programs to date. A central problem has been that upon establishment of the reserves, managers only received control over the birds and their nests, not their habitats. To be successful, the reserves must work in cooperation with local governments to educate local people about resource use and to guide development.



Unfortunately, relations between protection staff and local governments can instead threaten conservation programs. The east side of Zhalong Nature Reserve, for example, is a vast reed marsh with ample water where workshop participants in 1987 saw hundreds of resting Siberian cranes. The Zhalong staff patrols this area but no longer controls hunting of waterbirds or the taking of eggs. The cranes alone are left unmolested, due to their international fame. Because only a single road provides access to the marsh, the hunting ban could easily be enforced; but local government leaders and their friends are the poachers.

Wetland reserves are particularly vulnerable to activities far from their borders because of the flow of water. For example, if the huge Three Gorges Dam is built on the Yangtze River, water flows and habitats will be altered in all the wetland reserves in the middle and lower reaches of the river, and perhaps most critically at Yancheng Nature Reserve on the coast north of the river's delta. At Yancheng, deposits of silt carried by the Yangtze to the sea expand coastal wetlands where most of the mainland's red-crowned crane population winters. If the silt flows are diverted, the reserve may literally vanish in the sea.

Similarly, proposed dam projects along the Amur River on the Soviet-Chinese border offer cheap electric power but could have devastating impacts on nesting marshes for red-crowned and white-naped cranes. Soviet-Chinese cooperation offers opportunities for conservation, but also may destroy much of the natural values of the Amur.

Crane conservationists cannot simply oppose development. Instead, let us all work toward finding the best ways for resource use, throughout China and the now transforming Soviet Union, across the vast southern Asian range of the sarus crane, in highly developed Europe and North America, and through temperate and tropical regions of Australia.

When the delegates left Qiqihar, we had decided that the next worldwide workshop would convene in Botswana during the latter part of 1992. Our hope is that the meeting will stimulate crane research and wetland conservation in the second largest of continents with six species of cranes. Plans are now well underway to hold that meeting. But it will not be a worldwide meeting in the sense that India was in 1983 and China in 1987. Our networks of crane conservationists have become so large and widely scattered that it is too expensive to bring everyone together in one place. The African meeting will include a few conservationists from other continents. But the future seems to lie with regional or specialized crane meetings, such as a workshop in Pakistan in December 1991 on the Siberian crane, the east Asian meeting which will convene on a boat on the Amur River in July 1992, and a meeting of captive breeding specialists planned for Canada in August 1992.

#### ACKNOWLEDGMENTS

The 1987 International Crane Workshop would not have been possible without the efforts of many. I wish especially to thank our hosts in China, the Wildlife Conservation Association, including Dr. Qing Jianhua, Mr. Bai Jingyu, Mrs. Chen Huiyuan and other officials of the Ministry of Forestry and the Heilongjiang Forestry Bureau. These agencies contributed significantly to the financing of the workshop. Hosting a bilingual conference, of such a large size and in a remote location, provided a unique challenge in logistics and communication. All the delegates join me in thanking Mrs. Zhao Zhongqin and her team of eight interpreters from China, and also Douglas McNeal and Jim Harkness, who transferred information day and night from English to Chinese and back again.

The travel costs for so many foreign delegates, to and from China, as well as workshop fees were covered in part by Japan Airlines, the United Nations Environment Programme, the U.S. Fish & Wildlife Service, World Wildlife Fund-International, and contributions of members of the International Crane Foundation.

Preparation of the proceedings has also depended upon many efforts. Li Chunyuan and Cao Yupu from the Heilongjiang Forest Bureau coordinated the selection of Chinese papers for the English version. At ICF, further editing and translation of the Chinese papers were performed by Gu Chao-hua, Wu Ling, and Su Liying. Su Liying redrew many of the figures. Mary Anne Bishop, Lois Harris, and Mary Ann Staniszewski assisted with editing of English papers. Sue Beal, Su Liying, Teresa Searock, and Mary Ann Staniszewski typed the manuscripts. Sheri Snowbank assisted with final proofing. George Archibald provided generous advice. Typesetting and layout were patiently completed by Tony Dunn of Tony's Studio.

Publication and distribution costs of the proceedings are being met by part of the workshop registration fees and by contributions of ICF members participating in overseas work expeditions to China in 1987, 1988, and 1989.

The cover logo, of a red-crowned crane, was designed by Zhalong Nature Reserve. The line illustrations used at the beginning of sections were drawn by Paul Tritaik.

A Chinese version of the proceedings has also been published: Forestry Bureau of Heilongjiang Province, ed. 1990. Proceedings 1987 International Crane Workshop. Forestry Publishing House of China, Beijing. This volume contains 32 Chinese papers from the workshop and 29 foreign papers.

1 November 1991

James Harris  
International Crane Foundation  
Baraboo, Wisconsin USA



## RESOLUTION ON ECONOMIC DEVELOPMENT PROJECTS AND WETLANDS VALUES AND PROTECTION

Resolution to all government agencies and development assistance organizations involved in planning, certifying and funding projects that cause permanent alteration to naturally wet environments:

WHEREAS conservation of not only cranes, but of all species of birds that utilize natural wetlands for feeding, reproducing and migratory resting places depends directly on conservation of these wetlands; and

WHEREAS natural wetlands not only support birdlife, but also slow down and spread out flood waters, permanently trap heavy metals and organic pesticides, purify the waters that flow through them of essentially all bacteria and human enteroviruses, remove poisonous nitrates leached from uplands, naturally trap silt for erosion control; and

WHEREAS natural wetlands produce quantities of organic matter equivalent to and often greater than those of our most rich forests and pastures and often directly support animals used for human food; and

WHEREAS natural wetlands, both salt and fresh, serve as breeding and nursery grounds for many fish, shellfish and crustaceans; and

WHEREAS natural wetlands produce potable water for use by humans with no cost to society; and

WHEREAS the wetlands of the world have traditionally, but erroneously, been held in low esteem by decision makers who are trained in other disciplines; and

WHEREAS past destruction of wetlands has resulted in loss of over half the original wetland areas of the world with concomitant loss of critical habitat for cranes and other waterfowl, increased flooding, siltation of dam reservoirs, loss of clean water supplies, loss of aquatic animal populations and nursery grounds, loss of wildlife habitats, loss of organic matter production, loss of groundwater and increased soil salinity in coastal areas;

NOW THEREFORE BE IT RESOLVED that we, the 225 Delegates representing 29 nations at the International Crane Workshop convened at Qiqihar, China, May 1-10, 1987, unanimously vote to:

CONGRATULATE the World Bank on its newly-implemented policies concerning sensitivity to long-term values and benefits of maintenance of both biological diversity and environmental services of ecosystem stability, which natural areas such as wetlands contribute, on all approved development projects, a welcome change from past policies;

URGE all government agencies and development assistance organizations that, for each water-related project conceived for the presumed benefit of peoples in developed and developing countries, the proposed development plan be:

1. EVALUATED carefully for its long-term adverse effects on people, cranes, and other wildlife that are generated by loss or change of wetland ecosystems before the development proposal is approved;
2. WEIGHED carefully against the proposed project in terms of both economic gain and environmental damage which must eventually be rectified at further expense;
3. MADE broad enough to include those additional costs of future action required to compensate for lost wetlands ecosystem values and functions;
4. EXPLAINED to affected parties and citizens of the country generally those ecological reasons for the approved plan, or, alternatively, the ecological basis for disapproval;
5. INCORPORATED whenever possible with establishment of new permanent wildlife preserves or restoration of previously degraded wetlands ecosystems;
6. UNDERTAKEN only if the results of these studies point up greater long-term advantages than disadvantages, and be done only in conjunction with strong efforts to mitigate any loss or damage to natural wetlands.

## RESOLUTION ON WETLAND DRAINAGE AND PEST CONTROL

WHEREAS wetlands have been recognized worldwide as vital ecosystems for a wide variety of bird species, including cranes and storks; and

WHEREAS competing demands for land use in pursuit of improving living standards of the people have put decision-makers under tremendous pressure to open up swamps for agricultural purposes; and

WHEREAS health problems caused by mosquitoes to millions of people have resulted in the drainage of swamps and river basins; and

WHEREAS the alternative to drainage is normally the use of persistent pesticides which also have negative environmental effects;

NOW THEREFORE BE IT RESOLVED that urgent and better education strategies be developed to inform the general public and the decision-makers that:

1. Swamps drained for agriculture rapidly lose their fertility and often permanently become highly acidic and incapable of supporting any plant life;
2. Draining of swamps results in decimation of wildlife locally and often worldwide, and causes extreme local conditions of flood and drought to be the rule rather than the exception;
3. Because of increased resistance to pesticides, spraying will never completely eradicate the targeted species and at the same time will rapidly remove all naturally-controlling predator species;
4. Using modern techniques of integrated pest management, programs of insect control can be developed without drastic ecosystem alteration.

## RESOLUTION REGARDING COOPERATION AMONG ZOOS FOR CAPTIVE BREEDING

WHEREAS zoos and parks of the world have an obligation to educate the public about wildlife and importance of wild habitat preservation; and

WHEREAS zoos are often the stewards of significant forms of wildlife, including storks and cranes; and

WHEREAS many zoos, because of their geographical location, political or other reasons find it difficult to exchange animals with one another; and

WHEREAS production of these birds can be increased by pairing cranes and establishing them in conditions conducive for captive breeding;

NOW THEREFORE BE IT RESOLVED that the International Crane Workshop strongly encourages zoos to cooperate with each other in an active program of pairing storks and cranes and putting them in suitable conditions for reproduction and further encourages zoos, wildlife biologists and government officials at all levels to cooperate closely on the captive breeding of all endangered animals.

## RESOLUTION ON CONSERVATION OF RED-CROWNED CRANES IN NORTHEAST CHINA

WHEREAS the rise and decline of a species is closely related to its breeding habitat; and

WHEREAS in China the breeding areas of the red-crowned cranes are mainly distributed in the northeast region; and

WHEREAS the results of extensive surveys indicate that vast areas of wetlands have been damaged or cultivated by human activities; and

WHEREAS it has been proved that red-crowned cranes never again breed in such reconstructed or cultivated land;

NOW THEREFORE BE IT RESOLVED that the following strategies for protection of the breeding habitat of red-crowned cranes and other water birds be developed:

1. To define some wetlands as absolute nature reserves, and to let the habitat operate naturally in order to further study the biological characteristics of red-crowned cranes and other rare water birds;
2. To control the water resources to keep the level of the marsh appropriate for a wetland;
3. To eliminate the damage and disturbances caused by human activities as much as possible;
4. To turn the cultivated lands, when not valuable for production, back to the original marshland, joining together the scattered pieces of wetland.

## RESOLUTION ON CONSERVATION OF EASTERN WHITE STORKS IN CHINA

WHEREAS the eastern white stork *Ciconia boyciana* breeds only in Soviet Siberia and the People's Republic of China (PRC) and winters only in the PRC; and

WHEREAS this species is recognized as a number one endangered species in the PRC and the Soviet Union;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop:

1. CONGRATULATE the PRC for its conservation efforts and urge the PRC to continue and expand its conservation programs for this species, including protection of breeding and wintering areas as well as important areas on the migration route. We also urge protection of nest sites from disturbance and the erection of nesting platforms. We recommend discouraging poaching and poisoning of waterfowl in the wintering area.
2. CONGRATULATE the Shanghai Zoo for its successful captive breeding program and urge zoos throughout the PRC to cooperate in developing strong captive breeding programs for the species.
3. URGE that the eastern white stork not be collected for export to foreign zoos and that extreme care be taken when young are collected for zoos in China, including collecting chicks only for zoos with adequate breeding facilities away from the exhibition area, and that at least two chicks be left in each nest.
4. ENCOURAGE cooperation with other centers to exchange breeding technologies.

## RESOLUTION ON POPULATION CONTROL AND CONSERVATION IN CHINA

WHEREAS expanding human population in China and many other countries of the world poses serious threats to wildlife resources and habitats; and

WHEREAS the People's Republic of China has the largest human population in the world; and

WHEREAS the People's Republic of China has recognized the need to control population size; and

WHEREAS the Government of China has instituted an aggressive plan of birth control for its population;

NOW THEREFORE BE IT RESOLVED that the 1987 International Crane Workshop congratulates the People's Republic of China for its recognition of the importance of human population control and taking appropriate measures to accomplish population control, and moreover encourages the People's Republic of China to continue its programs of preservation of wildlife resources and the conservation of natural habitats.

## RESOLUTION ON CRANE CONSERVATION IN HUNGARY

WHEREAS there is a good relationship between cranes and people in Hungary; and

WHEREAS although the cranes are not hunted, they are very sensitive to hunting and are disturbed by the shots of hunters pursuing other waterfowl; and

WHEREAS the Hungarian Government has established a list of protected areas so the cranes can find suitable resting places, with seven sites of the eight important resting places now under protection; and

WHEREAS due to the protection of birds and the resting sites, the number of roosting areas has increased in the last five years, and the duration of the cranes' stay in spring and autumn has increased as well;

NOW THEREFORE BE IT RESOLVED that all waterfowl hunting be banned during the crane migration period and near the resting sites;

AND BE IT FURTHER RESOLVED that the Biharmyra area, the eighth resting site, be restored to its importance in the crane migration as it was in the past by designating this area as a Ramsar site.

## RESOLUTION ON PROTECTION OF FUJIMAE TIDAL FLATS, NAGOYA CITY, JAPAN

WHEREAS many thousands of hectares of tidal flats in Ise-bay have been reclaimed for industrial development since the 1950s; and

WHEREAS Fujimae is the most important tidal flat of the remaining 300 hectares of tidal flats at the Nagoya Port, containing approximately 117 hectares; and

WHEREAS this tidal flat is one of the best habitats for migratory waterbirds, especially for waders (during twice-monthly censuses from February 1986 - February 1987, a maximum count of 34 species and more than 10,000 individual waders were recorded in this area; this number being the highest density among all tidal flat and wetland habitats in Japan); and

WHEREAS the Nagoya City government is planning a garbage reclamation project (West - 1 plan) on 105 hectares of the total 117 hectare area; this plan will effectively eliminate the entire tidal flat and thereby destroy this important migratory waterbird feeding area;

NOW THEREFORE BE IT RESOLVED that Nagoya City should stop its plan to destroy this area and seek alternatives;

AND BE IT FURTHER RESOLVED that the Fujimae tidal flats should be established as a sanctuary of international importance for migratory waders.

## RESOLUTION ON SIBERIAN CRANE STAMPS FOR THE SIBERIAN CRANE FLYWAY NATIONS

RECOGNIZING the importance of Public Education for developing support for crane conservation; and

RECALLING the resolution passed at the 1983 International Crane Workshop calling for Siberian Crane flyway nations to issue postage stamps dramatizing the endangered status of these birds; and

ACKNOWLEDGING the issuance of Siberian Crane stamps and the first day covers by India (1983), Pakistan (1983), China (1986) and Mongolia (1986);

NOW THEREFORE BE IT RESOLVED that the 1987 International Crane Workshop:

1. APPLAUDS India, Pakistan, China and Mongolia for issuing Siberian Crane stamps;
2. URGES the Soviet Union, Afghanistan and Iran to join its neighbors in issuing Siberian Crane stamps in sufficient quantities and proper denominations as to make them readily accessible and utilized by the general public.

## RESOLUTION ON CONSERVATION OF EASTERN SARUS CRANES IN VIETNAM

WHEREAS the eastern sarus crane *Grus antigone sharpii* is a large territorial avian species which needs wetlands for survival; and

WHEREAS the species was formerly a common inhabitant throughout southeast Asia, including Indochina, Thailand, southern China, Burma and Assam (India); and

WHEREAS the eastern sarus crane was thought to be extinct on the Asian continent until a remnant population was discovered in January 1987 in Dong Than Muoi, Vietnam; and

WHEREAS this population is presumed to breed in the wetlands surrounding Thonle Sap, Kampuchea, and is therefore a seasonal migrant within the region; and

WHEREAS the eastern sarus crane in Indochina is faced with numerous threats to its survival, including the loss of wetland habitat due to drainage and development for agriculture, human disturbance at its breeding sites, hunting pressure, and disturbance by military activity, and is therefore an endangered species throughout Asia;

NOW THEREFORE BE IT RESOLVED that the central and provincial governments of Vietnam take the following actions for the conservation of the eastern sarus crane in Indochina:

1. Establish a Sarus Crane Sanctuary in Dong Thap Muoi, Dong Thap Province, based on the recommendations of the State Program on Environment and Natural Resources (Program 52-D);
2. Promote further research in Dong Thap Muoi to clarify the species' status, ecology and movements;
3. Develop a cooperative arrangement through the State Program 52-D for vital research in critical crane breeding habitat in Thonle Sap region, Kampuchea;
4. Initiate surveys in northern Laos, where it is possible that the crane still exists;
5. Participate in a regional conservation effort for the eastern sarus crane with neighboring countries, including Laos, Kampuchea, Thailand, China, Australia and the Philippines;
6. Cooperate with international organizations interested in assisting with crane conservation in Vietnam, including the Brehm Fund (West Germany), International Crane Foundation (USA), and the International Waterfowl Research Bureau (England).

## RESOLUTION ON SARUS CRANE WORKING GROUP IN THAILAND

WHEREAS the eastern sarus crane *Grus antigone sharpii*, a large wetland bird of southeast Asia, southern China and Australia has become endangered on the Asian continent; and

WHEREAS most large wading birds have become rare in southeast Asia and are endangered in Thailand;

NOW THEREFORE BE IT RECOMMENDED that the establishment of an Eastern Sarus Crane and other large wading bird Working Group in Thailand be officially endorsed by the Wildlife Conservation Division of the Royal Forest Department.



## RESOLUTION ON CONSERVATION OF SIBERIAN CRANES IN WEST ASIA

WHEREAS the western breeding group of the Siberian crane *Grus leucogeranus* is highly endangered; and

WHEREAS this remnant group of 49-50 Siberian cranes is subdivided into two dangerously small flocks of 38 birds wintering in India and 11-12 birds wintering in Iran; and

WHEREAS hunting pressures, habitat destruction, and longstanding political differences along their international flyways place significant limitations on meaningful efforts to study and protect the western group of Siberian cranes; and

WHEREAS cranes' slow reproduction rate and monogamous nature provide further limits on the ability of these birds to recover; and

WHEREAS the slow but steady success of extensive multilateral research and educational efforts is acknowledged to rescue the whooping crane from the brink of extinction;

NOW THEREFORE BE IT RESOLVED that the 1987 International Crane Workshop:

1. URGES the leaders of the USSR, Afghanistan, Pakistan, India and Iran to direct and actively encourage their governments and national conservation organizations to promptly undertake all actions required to establish the exact migration paths and habitats crucial to the western breeding group of Siberian cranes;
2. FURTHER URGES said leaders to direct scientists in the respective countries cooperatively to study the feasibility of tagging 2-3 Siberian cranes in both western flocks with "state-of-the-art" techniques to allow satellite tracking of their migrations, by an independent, non-political, international scientific agency if necessary;
3. CALLS upon wildlife and education officials in the flyway countries to undertake public awareness campaigns along suspected Siberian crane migration paths to minimize hunting threats, to aid hunters in differentiating this highly endangered species from its more numerous cousins, and to seek the assistance of the general public in identifying these birds on migration;
4. REAFFIRMS the importance of wetlands to the ecological well-being of mankind, as well as to endangered international migratory birds like the Siberian crane; and
5. IMPLORES flyway countries to allow no drainage or destruction of wetlands which may be important to the survival of the Siberian crane.

## RESOLUTION ON A SARUS CRANE SURVEY IN INDIA

WHEREAS the threat to the sarus crane is increasing in India through the draining and heavy intrusion into wetlands; and

WHEREAS wetlands around cities are being used for dumping wastes; and

WHEREAS breeding areas for the sarus crane are rapidly disappearing and within a decade the sarus populations in the sub-continent will start to show a rapid decline;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop in Qiqihar, China recommend that the Government of India and the State Governments of Uttar Pradesh, Rajasthan and Gujarat have a census made of nesting Sarus Crane pairs during the 1987 monsoon rains.

## RESOLUTION ON SIBERIAN CRANE PROTECTION IN INDIA AND PAKISTAN

WHEREAS crane hunting in Pakistan may periodically threaten birds in the Indian wintering group of Siberian cranes; and

WHEREAS the crucial importance of Keoladeo National Park in Bharatpur, India, is recognized as the last known wintering ground of Siberian cranes in the subcontinent; and

WHEREAS there are inherent difficulties in protecting endangered species in highly populated, as well as remote, areas;

NOW THEREFORE BE IT RESOLVED that the 1987 International Crane Workshop:

1. APPLAUDS efforts of governmental agencies and conservation groups to protect the Siberian crane on migration and wintering grounds; and
2. URGES both countries actively to communicate news of the passage of Siberian cranes and other cranes to and from their borders as part of larger efforts to study and conserve wetlands for other aquatic migratory birds and sustainable development.

## RESOLUTION REGARDING RATIFICATION OF THE RAMSAR CONVENTION BY KENYA AND UGANDA

WHEREAS the Governments of Kenya and Uganda have enacted laws to protect wildlife resources; and

WHEREAS better management of wetlands will be achieved when the countries ratify the Convention on Wetlands of International Importance, especially waterfowl habitat; and

WHEREAS the Ramsar Convention recognizes the sovereign rights of the country, now and always, to manage and utilize wetlands in the manner that is deemed to be more consistent with the pursuit of national interests, with no new responsibilities assumed; and

WHEREAS Kenya and Uganda have won recognition as leading countries in the global movement to achieve a better management of the environment;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop urge the Governments of Kenya and Uganda to ratify the Ramsar Convention.

## RESOLUTION ON PROTECTION OF LAKE NAIVASHA, KENYA AS A NATURE RESERVE

WHEREAS the establishment of Lake Nobure and Lake Bogovia as bird breeding sanctuaries reveals the Government of Kenya's commitment to the conservation of birds in wetland ecosystems; and

WHEREAS Lake Naivasha has a high species diversity with over four hundred species using the lake habitats for breeding, roosting, feeding and stopping over during migration;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop formally express their appreciation to the Government of Kenya for its commitment to conservation; and

BE IT FURTHER RESOLVED that we urge and recommend that Lake Naivasha be declared a national reserve.

## RESOLUTION REGARDING CONSERVATION OF YALA SWAMP, KENYA

WHEREAS we appreciate the wisdom of the Kenya Government in its efforts to accommodate the needs of the Kenyans and wildlife in the Lake Victoria basin; and

WHEREAS the establishment of the Lake Basin Development Authority is one indication of the Government's commitment to develop the region; and

WHEREAS the Yala Swamp is particularly important due to endemic fauna and flora; and

WHEREAS the reserve would provide refuge to the displaced mammal species sitatunga *Tragelaphus spekei*;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop urge the Government of Kenya to spare part of the Yala Swamp as a wildlife conservation reserve; and

BE IT FURTHER RESOLVED that we urge the Government to conduct environmental impact assessments in the areas proposed for reclamation in the basin of Lake Victoria.

## RESOLUTION ON SUSPENSION OF LARGE BIRD TRADE IN KENYA

WHEREAS the Government of Kenya has set up the Ornithology Unit in the Department of Wildlife Conservation and Management; and

WHEREAS this reflects the importance the Government attaches to bird conservation in Kenya;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop commend the Government of Kenya for the establishment of the Ornithology Unit; and

BE IT FURTHER RESOLVED that we urge the Government of Kenya to suspend trade in large birds, particularly bustards and cranes, so as to allow the populations of these birds to rebuild.

## RESOLUTION ON HABITAT PROTECTION FOR GREY CROWNED CRANES IN UGANDA

WHEREAS the grey crowned crane is Uganda's national bird and is legally protected by the state; and

WHEREAS the numbers of grey crowned cranes could decline in the near future because of the loss of suitable breeding habitats; and

WHEREAS it is not only a proclamation that can save a species from extinction;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop urge the Government of Uganda to take urgent steps to impart maximum protection to the grey crowned cranes by setting aside some marsh areas where the grey crowned cranes are known to breed.

## RESOLUTION APPLAUDING ESTABLISHMENT OF THE MINISTRY OF ENVIRONMENT PROTECTION IN UGANDA

WHEREAS the delegates of the International Crane Workshop, gathered at Qiqihar, China from May 1-10, 1987 are aware that the task of preserving the environment as the hub of all social, economic and political activities rests in the people and their leaders; and

WHEREAS we realize that the ever-increasing human population requires adequate planning for a sustainable utilization of natural resources; and

WHEREAS we note the foresightedness of Uganda in taking steps to protect the environment for a sustainable utilization of resources;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop congratulate the Government of Uganda for setting up a Ministry of Environment Protection which we hope will work closely with other relevant ministries in the conservation of wetlands.

## RESOLUTION REGARDING RATIFICATION OF THE RAMSAR CONVENTION BY ZAMBIA

WHEREAS the Government of Zambia has made strides in the protection and conservation of wildlife resources; and

WHEREAS wetlands could better be conserved through ratification of the Ramsar Convention on Wetlands of International Importance, especially for waterfowl habitat; and

WHEREAS the convention recognizes the sovereign rights of the country, now and always, to manage and utilize wetlands in the manner which is deemed to be more consistent with the pursuit of national interests, with no new responsibilities assumed; and

WHEREAS Zambia has won recognition among the leading countries in the global movement to achieve a better management of the environment;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop urge the Government of Zambia to give full attention and take the necessary steps to ratify the Ramsar Convention as a primary step toward the conservation and management of wetlands.

## RESOLUTION ON WETLANDS CONSERVATION IN ZAMBIA

WHEREAS the Government of Zambia has been responsible for the formulation and implementation of the National Conservation Strategy, with specific objectives to maintain essential ecological processes and life support systems, preserve genetic diversity and ensure the sustainable utilization of species and ecosystems; and

WHEREAS the Government of Zambia has initiated the Wetlands Project with the World Wildlife Fund-International and the International Union for the Conservation of Nature, for the conservation and management of Kafue Flats and Bungweubu Basin; and

WHEREAS the objectives of the Wetlands Project include maintaining productivity of the two wetlands, improving and broadening the benefits that local people derive from wetlands, and mobilizing support for the conservation of living resources among local people through their active participation;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop congratulate the Government of Zambia for its progress to date; and

BE IT FURTHER RESOLVED that we urge the Government of Zambia to continue with the efforts being made, in particular, the strengthening of the Department of National Parks and Wildlife Service, establishment of the Environmental Council, implementation of the Non-pollution Act, and, based on the initial successful results, expansion of the wetlands project so as to allow for the development of further projects of other subjects and wetland areas.

## RESOLUTION ON CUBAN SANDHILL CRANE

WHEREAS the Cuban sandhill crane *Grus canadensis nesiotis* is listed under Appendix I of the Convention on International Trade in Endangered Species;

WHEREAS this subspecies is thought to still exist in low numbers; and

WHEREAS because of its unique upland nesting habits it may be threatened by agricultural and other human activities; and

WHEREAS there has been no information on the status of the Cuban sandhill crane available to the scientific community in more than 30 years;

NOW THEREFORE BE IT RESOLVED that the 1987 International Crane Workshop, meeting in Qiqihar, People's Republic of China, urges the Government of Cuba to undertake all necessary actions to protect the Cuban sandhill crane and its habitat; and

BE IT FURTHER RESOLVED that the International Crane Workshop urges the Government of Cuba to initiate a study to determine the status and ecology of the Cuban sandhill crane so as to assure its future survival; and

BE IT FURTHER RESOLVED that scientists attending the International Crane Workshop are willing to assist the Government of Cuba in any way that might be appropriate.

## RESOLUTION ON PROTECTION OF THE PLATTE RIVER AND WETLANDS IN NEBRASKA

WHEREAS the Platte River and associated wetlands in Nebraska, USA are one of the most important habitats for cranes of the world, hosting about 500,000 sandhill cranes and providing critical migratory habitat for whooping cranes; and

WHEREAS the Platte River and adjacent Rainwater Basin wetlands provide vital habitat for millions of shorebirds, waterfowl and other migratory birds, including bald eagles, least terns, and piping plovers; and

WHEREAS these migratory birds are of international importance, inhabiting portions of east Asia, Central America, and South America; and

WHEREAS the need to protect the cranes and other migratory birds is recognized through international treaties among the United States, Japan, Soviet Union, Mexico, Great Britain and Canada; and

WHEREAS the Platte River has many values of public interest which are dependent upon instream flows, including public and private recreational uses, recharge of underground water supplies used for irrigation and municipal purposes, preservation of water quality and maintenance of channel flow capacity, along with other ecological, educational and historic values; and

WHEREAS 70% or more of the historical natural flow in the Platte in central Nebraska is diverted annually, resulting in the loss of over two-thirds of the open river habitat, and the degradation of many other values of public interest associated with instream flows; and

WHEREAS proposed water development projects and human encroachment on existing wetlands threaten the future existence of this habitat for the international migratory bird resource dependent upon it;

NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop held at Qiqihar, China urge the governments of the United States of America and of the states of Nebraska, Wyoming, and Colorado to protect the remaining wetlands in the Rainwater Basin and to sustain instream flows of the Platte River in order to protect the habitat used by sandhill cranes, whooping cranes, waterfowl, waterbirds, and other migratory birds; and to protect other ecological, economic and cultural values of public interest dependent upon instream flows and wetlands.

## RESOLUTION ON CONSERVATION OF BROLGAS IN AUSTRALIA

WHEREAS the brolga *Grus rubicundus*, while still being relatively secure in northern Australia, is rare and restricted in distribution in Victoria; and

WHEREAS its decline in Victoria has been attributed to habitat modification and disturbance;

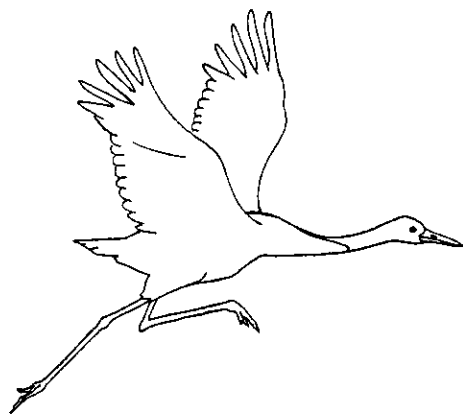
NOW THEREFORE BE IT RESOLVED that the delegates of the International Crane Workshop recommend that the following projects be initiated and undertaken by a Crane Working Group with assistance from the Department of Conservation Forests and Lands. These projects would provide critical, basic information necessary for the conservation of brolgas.

1. Identify the remaining wetlands where brolgas still breed successfully, using published records and existing information. Make recommendations on the retention and management of those wetlands.
2. Color band or mark young brolgas prior to fledging at selected breeding sites throughout their breeding range in Victoria.
3. Survey the brolgas at each flocking site during the flocking period to provide the following data:
  - a. Total population numbers
  - b. The movement of color marked birds from breeding sites to flocking sites and dispersal as they mature
  - c. The total number of brolgas produced every year
  - d. The relative value of each flocking site during drought and changing seasonal conditions.
4. Promote the conservation of brolgas and their habitat by public education and extension work directed toward landowners in particular.
5. In view of international concern that the sarus crane *Grus antigone* could replace the brolga in northern Australia, that a captive breeding program be undertaken to supplement the existing brolga population and reintroduce captive-reared birds to areas where they formerly occurred in southern Australia.



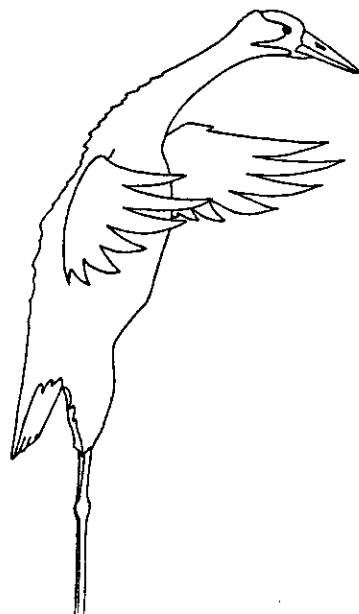


**PART I**  
**CHINESE PAPERS**





**CHAPTER 1**  
**GENERAL CONSERVATION**





## STATUS AND CONSERVATION OF CRANES IN CHINA

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### ABSTRACT

Nine species of cranes have been recorded in China, among them the sandhill crane *Grus canadensis* which is only occasionally seen in our country. There are at least six species that breed in China: the red-crowned crane *G. japonensis*, the white-naped crane *G. vipio*, the hooded crane *G. monacha*, the common crane *G. grus*, the black-necked crane *G. nigricollis*, and the demoiselle crane *Anthropoides virgo*. The possible breeding of the Siberian crane *G. leucogeranus* and sarus crane *G. antigone* in China will be studied in the future. An outline is given for the distribution and number of all crane species in China according to the investigations of recent years. The loving, raising and conserving of cranes in China has a long history. The paper presents a systematic synopsis of conservation of cranes in our country, including the conservation of their habitats.

Cranes are large waterbirds which have made important contributions to humanity's cultural development. There are 15 species of cranes in the world; among them, nine species have been recorded in China. China is the country which possesses the most crane species, and is also a pioneer country to love, raise, and conserve cranes.

Of the nine species of cranes recorded in China, at least six species breed in China. The sandhill cranes have only been seen occasionally in China as stragglers. Whether Siberian cranes and sarus cranes breed in China or not needs to be studied and investigated further.

According to our survey result, the resident situation of cranes in China is shown in Table 1.

### DEMOISELLE CRANE

Demoiselle cranes are the smallest cranes. According to past records, they were distributed in the Tian Mountains of western Xinjiang Autonomous Region, Ningxia Autonomous Region, Xingan, Zhelimu, Zhaowuda and Hulunbeir Districts of Inner Mongolia Autonomous Region, and near Qiqihar. They are summer migratory birds in these regions (Cheng 1976). According to the survey, a few nesting individuals were frequently seen in recent years on the semi-desert steppe in the four districts of Inner Mongolia (Tong and Tong 1986). They have been seen in eastern Qinghai Province, and Beidaihe of Hebei Province

English Name	Scientific Name	Residence Type <sup>a</sup>	Breeding Grounds	Wintering Grounds	Protection Class <sup>b</sup>
1. Demoiselle Crane	<i>Anthropoides virgo</i>	B,M,W	Xinjiang, Inner Mongolia and Northeastern China	Southern Tibet	II
2. Siberian Crane	<i>Grus leucogeranus</i>	M,W	Northeastern China (?)	Lower reaches of Yangtze River	I
3. Sandhill Crane	<i>Grus canadensis</i>	S		Occasionally in Jiangsu	
4. Sarus Crane	<i>Grus antigone</i>	R	Southwestern Yunnan Province	Southwestern Yunnan Province	I
5. White-naped Crane	<i>Grus vipio</i>	B,M,W	Inner Mongolia, Northeastern China	Lower reaches of Yangtze River	I
6. Common Crane	<i>Grus grus</i>	B,M,W	Northern Xinjiang and Northeastern China	South of Yellow River	II
7. Hooded Crane	<i>Grus monacha</i>	B,M,W	Northeastern China	Lower reaches of Yangtze River	I
8. Black-necked Crane	<i>Grus nigricollis</i>	B,M,W	Qinghai, Tibet, Gansu and Sichuan	Eastern Tibet, Yunnan, Guizhou, Sichuan	I
9. Red-crowned Crane	<i>Grus japonensis</i>	B,M,W	Northeastern China, Inner Mongolia	Lower reaches of Yangtze River, along the coast of Jiangsu	I

**Table 1.** The distribution of cranes in China.

<sup>a</sup> B-breeding, M-migrant, R-resident, S-straggler.

<sup>b</sup> According to "The Law of Protection of Wildlife Resources" (draft, 1984).

(a few) during migration periods. The only wintering ground known in China is in southern Tibet.

#### SIBERIAN CRANE

Siberian cranes have white feathers all over their bodies except the primaries which are black. So they are also called "black-sleeved cranes." Siberian cranes bred reportedly in areas around Hulun Lake of Inner Mongolia Autonomous Region, and Qiqihar (Lu and Li 1932; Meise 1934; Cheng 1976). According to Wilder's records, "This crane species bred in northeastern China. The egg diameter is 95 x 63 mm, and two eggs are in a brood" (Wilder and Hubbard 1938). Some birds were seen exhibiting breeding behavior in the outer reaches of the Wuyuer River in recent years (Li and Feng 1982), but no further evidence of breeding has been obtained. Thus, we now think this species is only a migratory and wintering bird in China.

During spring or autumn migration, the passing Siberian cranes can be seen at Zhalong Nature Reserve in Heilongjiang Province and over beaches of Beidaihe in Hebei Province. We know that these birds also stopover at Panjin in Liaoning Province and at the mouth of Luan River in Hebei Province. In March-April 1985, 652 northbound birds were recorded at Lotus Hill at Beidaihe (Williams et al., this proceedings); in October-November 1986, 192 were seen flying south past Beidaihe toward southern China. Those circumstances were similar to sightings of forty years ago (Hemmingsen 1951; Hemmingsen and Guildal 1968).

A majority of the wintering grounds of Siberian cranes are in the lower reaches of the Yangtze River, including Shengjin Lake in Anhui Province, Dongting Lake in Hunan Province and Poyang Lake in Jiangxi Province. The first two lakes have very few birds. Most of the Siberians winter at Poyang Lake, where 1,482 birds were counted in 1985, and 1,784 recorded in 1986 (Liu and Chen 1987b).

#### SANDHILL CRANE

The sandhill crane is also called brown crane. One bird was found in northern Jiangsu Province and was made into a specimen. Since then, this species has not been found in China. Therefore, we consider it to be a straggler.

#### SARUS CRANE

Sarus cranes are very large birds. A very few individuals of this species have been seen at Bangxi of Yingjiang County and at Mengla of Menglong County in Xishuangbanna Prefecture in western Yunnan Province (Peng and Wang 1965).

#### WHITE-NAPED CRANE

The scope of the breeding grounds for white-naped cranes in China is still unknown. The known breeding grounds include the lower reaches of Wuyuer River (Zhalong Nature Reserve), Xianghai Nature Reserve, and Dalinor of eastern Inner Mongolia Autonomous Region (see

Figure 1A). There are very few and scattered white-naped cranes in other areas.

In spring and autumn, the migratory route passes by Beidaihe beach in Hebei Province. In October 1985, 164 birds were recorded. In Dalinor, about a hundred birds were seen in fall (Feng et al., this proceedings).

The major wintering ground is around Poyang Lake, Jiangxi Province. A total of 1,165 birds were seen in 1985 (Archibald 1985), and 2,143 were seen in December 1986 (Jiangxi Daily, 13th December 1986). Based on banding materials, we know that a few individuals that breed in Zhalong of Heilongjiang Province pass through the Korean Peninsula to winter in southern Japan (see Yang, this proceedings).

#### COMMON CRANE

Common cranes are the most widely distributed crane (see Figure 1B). Breeding grounds of this species in China are in northwestern Xinjiang Autonomous Region, eastern Inner Mongolia Autonomous Region and the western part of northeast China. Breeding individuals were seen in northeast China, near Dalai Lake and along Wulijimuren River in Inner Mongolia Autonomous Region, and in Lindian County of Heilongjiang Province (Cheng 1976; Tong and Tong 1986; Li et al. this proceedings).

Common cranes pass through extensive areas lying to the north of the Yellow River during migration. As early as the 1940s, they were seen passing through Beidaihe beach during migration. A total of 4,250 birds were observed in the springs 1943-1945, and 20,139 birds in the autumns 1942-1945 (Hemmingsen and Guildal 1968). Although the number of this species has decreased over the 40-year period, they are still seen in spring and autumn. For example, 4,409 birds were recorded in spring 1985 (Williams et al., this proceedings) and 4,483 in autumn 1986.

The wintering grounds of common cranes cover extensive areas from the south bank of the Yellow River in southern Shanxi Province to Hainan Island and from Litang and Yajiang River in western Sichuan Province to coastal areas in the east. The areas known to have the largest flocks of wintering common cranes include the beaches of Yellow River in southwestern Shanxi Province where more than 2,000 birds were observed (Wang Fulin, this proceedings), Minquan in Henan Province, Hongze Lake in Jiangsu Province, Caohai in Guizhou Province (2,324 birds, Wu and Li 1986), Poyang Lake in Jiangxi Province (109 birds, Liu and Chen 1987a), Gejiu in Yunnan Province (327 birds in 1971, and 161 birds in 1978; Yang 1982).

#### HOODED CRANE

Breeding regions recorded in the past in China for hooded cranes were Ussuri River on the Sanjiang Plain and near Hailar of Hulunbeir in Inner Mongolia (Cheng 1976). But nests and eggs of hooded cranes have not been discovered in recent years. The species passes Beidaihe during migration. In spring 1985, 309 birds were recorded, and 527 in autumn 1986 (Williams et al., this proceedings).

The main wintering grounds are along lower reaches of the Yangtze River (see Figure 1C). A few individuals have been seen at Caohai of Guizhou Province (Wu Zhikang 1986, pers. comm.). The main wintering population has been seen at Shengjin Lake, Anhui Province (200 birds, Wang and Ma 1987), Poyang Lake, Jiangxi Province (210 birds, Liu and Chen 1987a), and Junshan, Dongting Lake of Hunan Province (48 birds, Wang and Ma 1987).

#### BLACK-NECKED CRANE

Black-necked cranes breed on the Qinghai-Tibet Plateau (see Figure 1D). Breeding grounds are mainly on grassy marshlands with an elevation of 4000 m. Distribution is extensive, from Qilian Mountains in the north to the upper Kulu River in southern Tibet and from the foot of Gangdisi Moun-

tains in the west to Songpan Roigai of northern Sichuan Province in the east. Wintering grounds with substantial numbers of birds include: river beaches near Xigaze Prefecture of Tibet, where 432 birds were seen in December 1983; northwestern Yunnan, according to investigations during November and December 1981, with 64 birds in Zhongdian, 5 in Lijiang, and 53 in Ninglang; and Huizhe county of northeastern Yunnan, with 58 birds recorded in January 1983 (Lu 1986). And there are another 305 birds in Caohai, Guizhou Province (Wu and Li 1986). Thus, the number of black-necked cranes in China is known to be more than 900.

#### RED-CROWNED CRANE

The red-crowned crane is the most loved of crane species by the Chinese people. This species was historically very

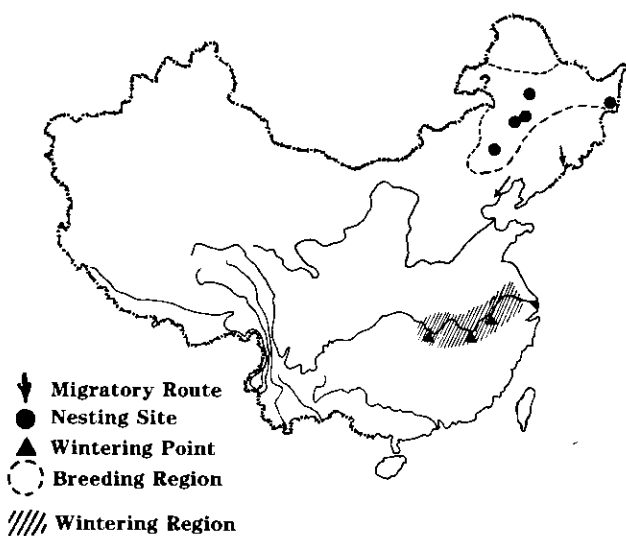


Figure 1A. Distribution of white-naped crane in China.

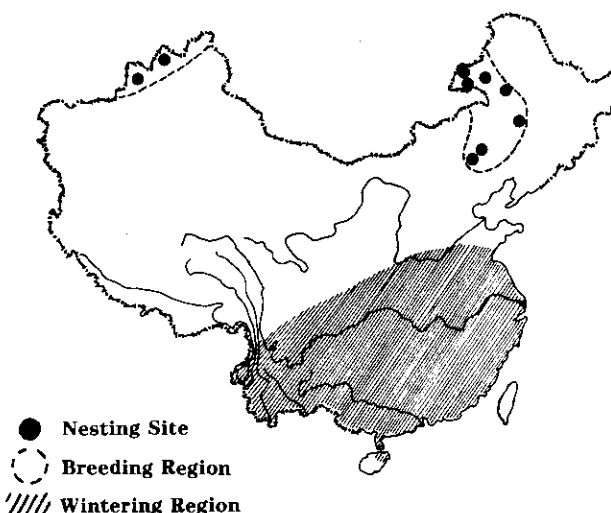


Figure 1B. Distribution of common crane in China.



Figure 1C. Distribution of hooded crane in China.

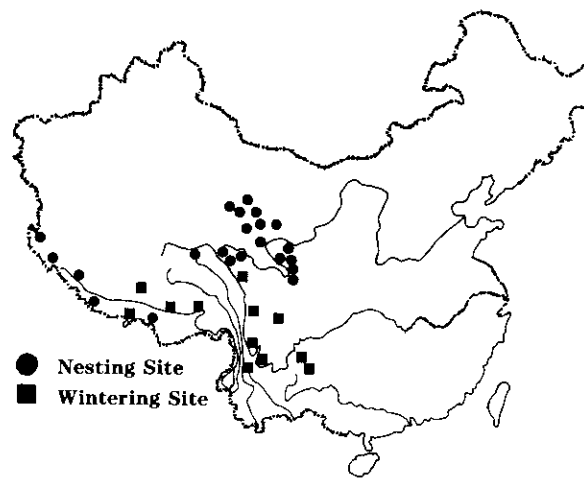


Figure 1D. Distribution of black-necked crane in China.

widely distributed in eastern China, and wintering individuals were seen in Taiwan and northern Yunnan Province. Based on aerial and ground surveys in recent years, there are presently nine concentrated nesting sites in northeast China (see Ma and Li, this proceedings).

Little study has been done on the migration of the species. Forty years ago (1943-1945) passing flocks were found at Beidaihe, Hebei Province; the southbound migrating population in autumn numbered 353 birds (Hemmingsen and Guildal 1968). Williams et al. (this proceedings) recorded 244 in spring 1985; in autumn 1986, 501 birds were recorded.

The wintering grounds for red-crowned cranes are mainly in the coastal areas in Jiangsu Province where Yancheng Nature Reserve for cranes and waterfowl was established in 1983. The wintering number of red-crowned cranes seems to be increasing somewhat in recent years. For example, there were 472 birds in 1984-85, 575 birds in 1985-1986; and 616 birds in 1986-1987 (Yan 1987). In addition, a few individuals were seen on Chongming Island near Shanghai which lies on the lower reaches of the Yangtze River, at Gaoyou Lake in Jiangsu Province, and at Shijiu Lake in Anhui Province.

#### LOVING AND RAISING CRANES

There is a long history of loving, raising, and conserving cranes by Chinese people. Many facts have been recorded in ancient literature.

The archaeologists of China excavated a queen's tomb from the Yin Dynasty of the 12th century B.C. and unearthed many cultural relics. Among them were jade carved cranes. It is evident that it was popular to love cranes as early as the 12th century B.C. Another early record comes from "The Book of Songs," in which there is a poem about crane's calling. It reads, "Cranes call on the flowering fields beside the vast swamp, the voice can be heard in the whole wilderness." This poem was meant to urge the Emperor Zhou Xiuanwang (he reigned from 872-782 B.C.) to go down to the grass (low) level to look for persons of virtue. The poem truly recorded the living habits and environment of red-crowned cranes.

During the Zhou Dynasty, raising cranes was in fashion. According to "The Book of Rites," the kings of every state all had enclosed parks, which were managed by especially appointed men. Many animals were kept there, and they could stroll freely within the range. These animals also included wild ducks and cranes. According to the "Zuo Biography," the king of We State, Wei Yigong (who reigned from 668-660 B. C.) liked to raise cranes. The book noted that "All the cranes that he was raising had certain official titles and official's salary. Among them, the First Class crane could get the salary of a senior official. The lower classes would be treated the same as lower class officials." These cranes were divided into teams and were carried on horse-drawn carriages when the king went out of palace for tours. They were called "crane generals." Later on, when another nationality from the north invaded his country, however, the people of the state were not willing to

resist the enemy. And they said, "Let crane generals resist the invasion." The state was defeated as a result of cranes. This was, of course, the king's mistake, and we cannot lay the blame on the cranes.

Following the Zhou Dynasty, raising of cranes was a fashion among the nobilities as well as among ordinary people. Based on "The Brief Annotation of Poems" written by Lu Ji, "the people of Wu Guo State all raised cranes at their homes" during the Sanguo (three kings) Dynasty (around the 2nd century A. D.).

About the methods used to raise and train cranes, Tu Long, who was successful in the highest imperial examination in the Wanli times of the Ming Dynasty, wrote a book to describe them in detail. One part of the book noted, "Those cranes raised, living in a circular thatched cottage neighboring a pool, were fed fish and grains. You shouldn't overfeed the cranes with cooked food to make them dispirited and inert.

"If you want to teach cranes to dance, put food on the ground when cranes are hungry, and let a child clap his hands and bounce cheerfully to guide the cranes. Then the cranes will move up and down. This is called food training."

The custom of raising cranes was continuously recorded until the late Qing Dynasty (1840), "Two cranes are put in the garden and fed food. Cranes have a long neck, high toes, and no ordinary markings. Cranes are fond of bathing and dancing after raining."

According to incomplete statistics, captive cranes at zoos and nature reserves in China now total more than 1,000. Except for sandhill cranes our other species are in captivity all in China.

#### PROTECTION EFFORTS

Although the literature and materials of every dynasty in China mentioned the protection of birds, concrete laws for protecting cranes were developed only after the new China was founded. The state council approved the proposal submitted by the Cultural Liaison Committee With Foreign Countries to export rare and precious animals of our country in 1959, and designated the red-crowned crane as a first-class valuable and special animal. It was specified clearly that "the species cannot be exported." When there is a necessity to present some as gifts, the process must be supervised by the Central Committee (No. 78 document of the Foreign Office of the State Council). In addition, item 18 of the "Temporary Provisions for the Hunting Management of Heilongjiang Province," which became effective on 6 May 1959, strictly prohibited hunting of cranes. In 1962, the State Council issued an instruction to "actively conserve and reasonably utilize resources of wildlife," strictly to prohibit hunting of red-crowned cranes and other precious birds, and to set up some nature reserves in their main habitats. In 1983, the State Council promulgated a general order again concerning strict protection of rare and valuable wildlife, including red-crowned cranes, black-necked cranes, Siberian cranes and other crane species. The "draft law on wildlife protection of China," 1986, included all the eight species of cranes now found in China and classified them as protected animals.



Our country had set up 18 nature reserves, up to the end of December 1985, with the main purpose to protect the habitats of cranes (see Table 2, and Figure 2). Most of the crane species in China are migratory. The national and regional crane protection organizations were formed in succession in 1983 and early 1984, and activities are carried out every year in order to improve conservation of cranes.

The "National Natural Science Fund," as well as the departments concerned, have allocated research funds to aid the study of cranes. Some programs have made important achievements, providing a scientific basis for crane protection. Some programs are still being carried out. We should point out that the great achievements made in conservation of cranes in recent years are due greatly to the enthusiastic help and support of the International Crane Foundation and many other friends. We will treasure their friendship and help. With the inspiration of this workshop, we will be able to bring our work in research and protection of cranes to a higher level.

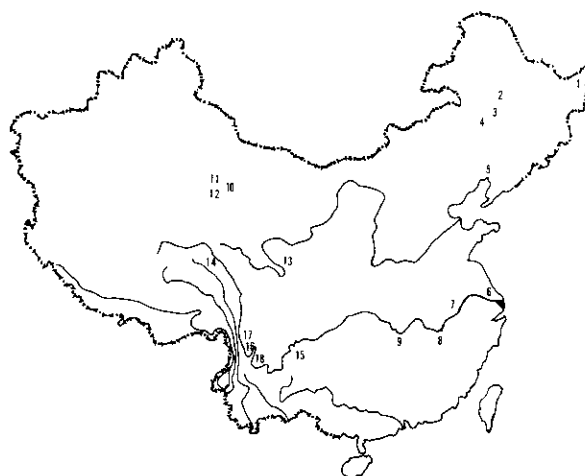


Figure 2. Location of nature reserves for cranes in China.<sup>a</sup>

<sup>a</sup>Numbers on map refer to nature reserves numbered and listed in Table 2.

Name	Locality	Area (ha)	Species	Date Established
1. Honghe Nature Reserve	Tongjiang County, Heilongjiang Province	16,333	Red-crowned Crane	1984
2. Zhalong Nature Reserve	Qiqihar City, Heilongjiang Province	42,000	Red-crowned Crane White-naped Crane	1979
3. Momoge Nature Reserve	Zhenlai County, Jilin Province	144,000	Red-crowned Crane	1981
4. Xianghai Nature Reserve	Tongyu County, Jilin Province	106,467	Red-crowned Crane Demoiselle Crane	1981
5. Shuangtai Nature Reserve	Dawa County, Liaoning Province	54,000	Red-crowned Crane	1985
6. Yancheng Nature Reserve	Yancheng City, Jiangsu Province	46,670	Red-crowned Crane	1983
7. Shengjin Lake Nature Reserve	Dongzhi County, Anhui Province	8,670	Hooded Crane White-naped Crane	1985
8. Poyang Lake Nature Reserve	Yongxiu County, Jiangxi Province	22,400	White-naped Crane Siberian Crane Hooded Crane	1984
9. Junshan (Dongting) Nature Reserve	Yueyang County, Hunan Province	84,000	Hooded Crane White-naped Crane	1982
10. Ganhaizi Nature Reserve	Yumen City, Gansu Province	300	Black-necked Crane	1982
11. Small Suganhu Nature Reserve	Akesai Hasake Autonomous County, Gansu Province	850	Black-necked Crane	1982
12. Big Suganhu Nature Reserve	Akesai Hasake Autonomous County, Gansu Province	3,500	Black-necked Crane	1982
13. Gahai Nature Reserve	Luqu County, Gansu Province	3,500	Black-necked Crane	1982
14. Longbaotan Nature Reserve	Yushu County, Qinghai Province	4,500	Black-necked Crane	1984
15. Caohai Nature Reserve	Weining County, Guizhou Province	3,200	Common Crane Black-necked Crane	1984
16. Bitahai Nature Reserve	Zhongdian County, Yunnan Province	4,133	Black-necked Crane	1984
17. Napahai Nature Reserve	Zhongdian County, Yunnan Province	2,067	Black-necked Crane	1984
18. Lugu Lake Nature Reserve	Ninglang County, Yunnan Province	8,133	Black-necked Crane	1984

Table 2. The nature reserves for cranes in China (up to December 1985).

Total Area = 554,723 ha.

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# THE IMPORTANCE OF WETLANDS IN PROTECTING BIRDS

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## ABSTRACT

Wetlands are the most important habitat for protection of birds. From 1979 to 1984, we studied the ecology of the large wading birds and made two aerial surveys over the marshlands and wetlands of Heilongjiang. Results show that changes of the wetlands affect the birds. There are three major wetlands in Heilongjiang Province, covering an area of over 3,000,000 ha. The wetlands have rich water resources, aquatic plants, and aquatic animals including shrimps, spiral shells, and insects. There are over 110 species of birds, including five endangered species such as the red-crowned crane *Grus japonensis*, white-naped crane *G. vipio*, and white stork *Ciconia ciconia*. The wetlands support a large number of birds with rich food and good places for resting and breeding. Because of the activities of people, the marshlands have been cultivated as farmland. The most important prerequisite for the large wading birds is the condition of the wetlands. If the wetlands are destroyed or fade away, the number of the birds will decline, and species will disappear. When people tamper with the wetlands, ecological considerations must be kept in mind to assure the survival of the aquatic birds.

Wetlands have an important role in the protection of birds. In 1979-1984, we studied the ecology of the red-crowned crane and other birds in the marshlands of the Wuyuer River Basin. In 1981, we conducted an aerial survey in the marshlands of the Wuyuer River for the first time, and in 1984, we conducted an aerial survey of the marshlands of all Heilongjiang Province.

The three major marshlands of Heilongjiang Province are distributed over the west and east. The Nen River—Wuyuer River marshlands in the west is located at 45°30'—47°40' N, 123°00'—125°00' E, and is about 1,000,000 ha. Two stretches of marshlands are in the east. One is the Qinxing, Noali, Shonghua, Wutong, Dulu Rivers Basin, located at 46°30'—48°30' N, 131°30'—135°00' E. The area is about 1,500,000 ha. The other marshland is Xiao Xingkai Lake wetland of Songacha River Basin, located at 45°00'—46°30' N, 132°00'—134°00' E. The area is over 200,000 ha. Other than these, there are other wetlands, smaller in area and somewhat scattered.

The water in the wetlands varies in depth from several cm to 4-5 m. Mobile river courses and small lakes vary in size. The structure of the river system is rather complex, and includes two major wetland types: one is reed marshes in grasslands, and the other is sedge meadows. The Wuyuer River wetlands are reed marshes in grass, and the major plant is the reed *Phragmites communis*, and also *Carex* spp., *Glyceria spiculosa*, wild rice *Leersia oryzoides*, cattail *Typhus*, oriental water plantain *Alisma plantago-aquatica* var. *orientale*, and algae, etc. Water animals rely mainly on crucian carp *Carassius auratus*, minnow *Phoxinus phoxinus*, snakehead *Perccottus glehni*, loach

*Misgurnus fossilis* etc. (more than 40 species) along with shrimps, spiral shells, insects, and larvae. These areas provide the birds with rich food and a good place for resting and breeding.

The major birds that dwell on the wetland are waterfowl (ducks and geese) and long-legged wading birds. There are also a few sparrow-like birds. More than 110 species inhabit the wetlands of Heilongjiang Province, accounting for nearly 10% of the total number of our country's birds, and nearly 30% for our province. Half of them are breeding and half of them are migrating birds. There are a large variety of rare birds. Results of aerial surveys on the rare wading birds from 5 to 18 May 1984 are shown in Table 1. Among these, red-crowned crane, white-naped crane, white spoonbill

Species	Wuyuer 2044 km <sup>a</sup>	Qixing- Dulu 2250 km <sup>a</sup>	Xiao Xingkai 1140 km <sup>a</sup>	Total
Red-crowned crane	189	260	13	462
Siberian crane	570	21		591
White-naped crane	17	9	2	28
Common crane	2	3	2	7
White stork	3	68		71
Black stork	4			4
White spoonbill	43	34		77
Oriental ibis	5			5
Whooper swan	1	80		81
Great egret	67	91	10	168

Table 1. Numbers of rare water birds, aerial survey, 5-18 May 1984.

<sup>a</sup>Transect distance.

*Platalea leucorodia*, oriental ibis *Threskiornis melanocephalus*, whooper swan *Cygnus cygnus*, and great egret *Egretta alba* are breeding birds. We must especially indicate that the number of red-crowned cranes resting here accounts for 50% of the mainland Asia total. During migration, a large number of Siberian cranes *G. leucogeranus* rest here. The resting time is long ranging from early April to mid or late May, according to our observations in 1981.

Five species of birds resting in the wetlands of Heilongjiang Province have already been placed in the Red Data Book for endangered birds of the world (King 1981). They are white stork, Siberian crane, white-naped crane, hooded crane *G. monacha*, and red-crowned crane. In addition, there are many other birds directly used by people such as geese, ducks and sandpipers.

The most important condition for large numbers of breeding long-legged waders is the wetlands. If the wetlands are destroyed, the number of birds will be reduced and disappear altogether. In spring of the early 1950s, people picked out bird eggs in the unexploited wetlands of the Shanjiang Plain and Wuyuer River Basin. One person could pick 50-100 kg every day, equal to 1000-2000 eggs. There were waders at that time, but now it is difficult to see them. In the 1940s, there were Japanese crested ibis *Nipponia nippon* in Xiao Xingkai Lake Wetland. For nearly 40 years, they have not been sighted there, due to human exploitation of the wetland.

In recent years, people have begun to see the importance of protecting the environment, and have carried out certain protective measures for the wetlands, such as setting up nature reserves. Heilongjiang Province set up Zhalong Nature Reserve on the wetlands of the Wuyuer River Basin. When the nature reserve was set up, we made the first aerial survey. The main species found was the red-crowned crane (the major protection goal for the reserve). The second aerial survey was made in 1984. The number and density of red-crowned cranes were similar in the two years (see Table 2), but the main breeding region of red-crowned crane in 1984 moved to the north, in comparison with 1981. The reason for this is that some marshlands in the south have been cultivated as farmland, which has had some effect on the breeding red-crowned cranes. The effects are not very serious, however, and these questions are being solved. From the table, we also can see the number and

the density of nesting cranes are rather steady and the total number is rising. The investigation shows no evident change to the distribution of other birds, illustrating the protective effect of the nature reserve.

Year	No. individuals			Area km <sup>2</sup>	Density km <sup>2</sup> /bird	Comments
	Sub- Adult	adult	Total			
1981	150	23	173	1818	10.5	South and southeast parts of the areas surveyed in 1981 were partially drained in 1984 after construction of a dam.
1984	151	38	189	2044	10.8	

**Table 2.** Results of aerial surveys of red-crowned cranes, Wuyuer River Basin.

The present condition of Heilongjiang Province's wetlands is not yet satisfactory. In the 1984 aerial survey, we used the latest 1/100,000 map published by the Survey Bureau of Heilongjiang Province in 1979. According to the plan, we should have surveyed 4000 km<sup>2</sup> in Qixing and Naoli Rivers Basin, but we could only survey 1510 km<sup>2</sup>. The Wutong and Dulu Rivers region should have included 2400 km<sup>2</sup> of wetlands, but we actually surveyed 740 km<sup>2</sup>. The wetlands in these areas have been reduced by 3/5 and 2/3 respectively. Many wetlands of that region have been replaced by farmland and water. Only one or two waders could be seen occasionally in the marshy fields. They surely cannot rest there steadily because of the influences of human productive activities. During our investigation, we saw burning grass on waste lands at several sites on the verge of the wetland. There is great concern about the speed of cultivating the wetland. As a result, only small marshes remain for breeding, and such conditions often cause the formation of local high-density areas. This habitat, in "isolated islands," has great disadvantages for the red-crowned crane population.

We protect wetlands and waders. Waders are the most precious wealth given to humanity by nature, and we have no reason to ignore or injure them. We must consider the ecosystem balance for wetlands when we cultivate the wetlands out of necessity. This care will enable us to conserve wader resources, and allow the wetlands to be used by humans.

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## CRANE BANDING IN CHINA

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### ABSTRACT

In 1985 and 1986, cranes were banded at the Caohai Nature Reserve in Guizhou Province, the Zhalong Nature Reserve in Heilongjiang Province, and Ruoergai in Sichuan Province. Of the 17 banded cranes, there were 4 black-necked cranes *Grus nigricollis*, 8 red-crowned cranes *G. japonensis*, 1 common crane *G. grus*, 1 white-naped crane *G. vipio*, and 3 demoiselle cranes *Anthropoides virgo*. A black-necked crane banded in the winter place in Caohai was seen coming back the following winter to the very same place. The banders at Zhalong once found, while observing the banded cranes, a white-naped crane wearing a yellow ring marked "J17." The bird had been banded at Izumi on Kyushu Island, Japan. As the Asian cranes migrate from one country to another, it is necessary to cooperate in these studies. Banding efforts are valuable to the studies on crane migration in Asia.

### INTRODUCTION

Nine of the world's 15 crane species have been found in China, among which the sandhill cranes *Grus canadensis* are only seen on rare occasions, a straggler from the north. The black-necked crane is the only crane species which lives on high altitude plateaus. Black-necked cranes breed in marshlands around lakes on the Qinghai-Tibet Plateau and winter in wetlands on the Yunnan-Guizhou Plateau. Other species, such as the red-crowned crane, white-naped crane, hooded crane *G. monacha*, common crane, and demoiselle crane breed in northeast China. The Siberian crane *G. leucogeranus* breeds in Siberia. Except for the demoiselle, these species all winter along the middle and lower reaches of the Yangtze River. Only the sarus crane *G. antigone*, of tropical wetlands, is non-migratory.

The crane species living in China can be adequately protected only after analyzing the information obtained from research on breeding grounds, migrating routes, wintering grounds, type and time of migration, as well as the life history of cranes by means of banding, observation and recovery.

The National Bird Banding Center of China (NBCC) is an official department under the Ministry of Forestry of China. It was established in 1982. NBCC organizes and instructs scientists and bird banders for banding of birds in all of China. NBCC not only provides metal rings and tools for banding birds, but also is in charge of exchanging banding information inside and outside of China. All banding records and recoveries are collected by NBCC. This paper summarizes reports of crane banding in China.

### RESULTS

In January 1985, black-necked cranes living in Caohai Nature Reserve were banded in Guizhou Province, China. This was not only the first time to band black-necked cranes in China, but also the first record for banding any cranes in China. In 1985-86, black-necked cranes were banded at Caohai Nature Reserve in Guizhou Province and Heihe Pasture in Rouergai in Sichuan Province. Red-crowned, white-naped, and demoiselle cranes were banded in Zhalong Nature Reserve in Heilongjiang Province also in 1985-86.

Of the 17 banded cranes in 1985 and 1986, there were four black-necked cranes, eight red-crowned cranes, one common crane, one white-naped crane and three demoiselle cranes (see Table 1).

The researchers from Caohai Nature Reserve observed that the black-necked crane banded on 26 January 1985 returned to its wintering ground in Caohai the following winter.

The banders at the Zhalong Nature Reserve discovered, while observing banded cranes, that the white-naped crane which was wearing a yellow band marked "J17," bred in the marshlands in Zhalong Nature Reserve. This banded white-naped crane appeared with its mate in 1984. Only "J17," however was seen in 1985. He came back again to breed in Zhalong in 1986. The National Bird Banding Center of the People's Republic of China informed the Japanese Bird Banding Center about this recovery. According to information obtained from the Sino-Japanese Banding Cooperation, the white-naped crane marked "J17" (male)

was banded by the Yamashina Institute for Ornithology at Izumi on Kyushu Island in Japan. This is the only significant wintering site for white-naped cranes in Japan, with over 1,000 each year (see Ozaki this proceedings).

On 27 January 1985, "J17" was seen going back to the wintering ground in Japan. Through the cooperation of banding, observation and recovery between China and Japan, the white-naped crane's migration between its breeding ground in China and the wintering ground in Japan have been identified without doubt. According to banding recovery information from Japan, the female (J18) of the white-naped crane pair died and its body was recovered in South Korea on 11 March 1985. As a result, the white-naped crane's migrating routes in China, Korea, and Japan have been identified through banding.

#### FUTURE COOPERATION

As cranes in Asia migrate from one country to another, it is necessary for these countries to cooperate and pay much attention to exchanging information about banding and recovery, and to inform each other on the methods of

banding used by these countries. Such cooperation includes timely notice to the other countries of the species of banded cranes, the banding numbers and the times of migration. This exchange is essential for research on migration patterns of cranes in Asia.

Since the signing of the Sino-Japanese Agreement on Migratory Birds Protection, the Sino-Japanese Banding Exchange and Cooperation have been in progress in both countries. In January 1986, the researchers of the two countries worked together at the crane wintering habitat in Izumi on Kyushu Island in Japan. They found white-naped cranes and hooded cranes banded in U.S.S.R. During the Sino-Japanese cooperative banding investigation, both parties proposed that China, Japan, and other Asian countries including the Asian part of the U.S.S.R. cooperate and investigate together, so as to have a good grasp of the migration patterns of cranes.

We propose, at this international academic conference on cranes, that an Asian cooperative investigation group for crane banding be formed. The NBBCC will try its best to support and actively take part in this international research and cooperation.

Species	Band Number		Sex	Age	Date	Place	Bander
	Color	Metal					
Common crane	No:31	M00-2501			26 Jan. 1985	Caohai	Li Ruoxian
Black-necked crane	Red 100	N00-0501	Male	1 Year	26 Jan. 1985	Caohai	Zhang Fuyun Wu Zhikang Lu Jun
Black-necked crane	Red 138	N00-0502		1 Year	25 Mar. 1985	Caohai	Li Ruoxian Wu Zhikang
Black-necked crane	Red w/o #	—		3 Day	16 June 1986	Ruoergai	Li Dehao
Black-necked crane	Red w/o #	—		3 Day	16 June 1986	Ruoergai	Wu Zhikang
Red-crowned crane	Red 35	Q00-0101			27 Sep. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Red 121	Q00-0142			11 Aug. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Red 122	Q00-0161			15 Aug. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Red 123	Q00-0124			16 Aug. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Red 124	Q00-0156			11 Aug. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Red 125	Q00-0120	Male	1 Year	27 Sep. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Red 128	Q00-0123		1 Year	9 Sep. 1985	Zhalong	Xu Jie / Su Liying
Red-crowned crane	Yellow 17	Q00-0158	Female	1 Year	2 June 1986	Zhalong	Xu Jie / Su Liying
White-naped crane	Red 25	Q00-0128	Female		16 Aug. 1986	Zhalong	Xu Jie / Su Liying
Demoiselle crane	—	M00-3304		1 Year	20 Sep. 1986	Zhalong	Xu Jie / Su Liying
Demoiselle crane	—	M00-3305		1 Year	20 Sep. 1986	Zhalong	Xu Jie / Su Liying
Demoiselle crane	—	M00-3317		1 Year	20 Sep. 1986	Zhalong	Xu Jie / Su Liying

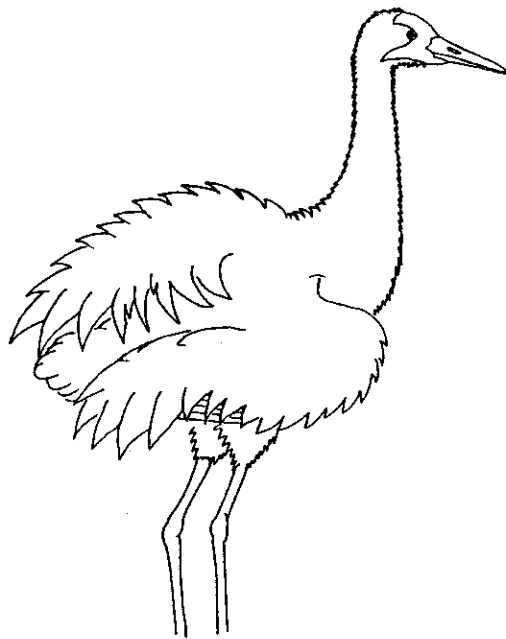
Table 1. Cranes banded in China.

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**CHAPTER 2**  
**SUMMERING AREAS**





## THE NUMERICAL DISTRIBUTION OF RED-CROWNED CRANES IN CHINA

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### ABSTRACT

To define the numerical distribution of red-crowned cranes *Grus japonensis*, we made aerial surveys by light aircraft in May of 1981, 1984 and 1986 over the breeding grounds of the cranes. The total aerial distances exceeded 8,000 km; the surveys covered over 420,000 ha. We have also done some ground surveys of migratory cranes and of cranes on their wintering grounds. According to survey data and some reference materials, the breeding range of the red-crowned crane has eight main regions in China. The number and distribution of red-crowned cranes on these breeding grounds are as follows: Honghe Nature Reserve, 51; Qixing River Basin, 176; lower reaches of Dulu River, 23; Xingkai Lake Lowland, 59; Wuyuer River Basin, 193; Hui River Basin, 38; lower reaches of Taoer River, 50; the mouth of Shuangtaizi River, 30. The total is 620 red-crowned cranes on the breeding grounds.

The red-crowned crane is a typical migratory bird in China. It migrates south for winter in the last ten days of October. Thus the red-crowned crane stays on the breeding grounds for about seven or eight months. The numerical distribution of the red-crowned crane has not been well documented. The Wildlife Resources Survey Office of Heilongjiang Province surveyed the distribution of the red-crowned crane first in 1974-1976 in the Nenjiang River Basin and Sanjiang Plain. The survey, however, was too rough to guide protective measures. In order to determine the distribution of red-crowned cranes on their breeding grounds, surveys were made by air in May 1981, 1984, and 1986 in China.

### CENSUS METHOD

Aerial surveys were conducted over the lower reaches of the Wuyuer River during the last ten days of May 1981, over the Sanjiang Plain in May 1984 and over the Hui River Basin in May 1986 in northeastern China. May is the latter brood period of the red-crowned crane; at this time the parent birds do not move far from their nest, and therefore they are easy to count.

We used a type Y-11 aircraft — a light twin engine plane which can take off and land on a short runway, with a good field of view and safe for ultra-low altitudes. The survey flight transect width was 1-2 km (0.5-1 km/side). The results were recorded on a map with transect mark lines and all transects were numbered. After each day's survey was completed, we discussed the results immediately, eliminated duplicate locations, and defined the numbers of the red-crowned crane of that area. The total transect distance exceeded 8,000 km, covering over 420,000 ha.

The numerical distribution of the red-crowned crane in Jilin and Liaoning Provinces and in the winter grounds were determined by ground surveys.

### NUMBERS ON THE BREEDING GROUNDS

The red-crowned crane is a typical summer bird in northeastern China. Data from ground surveys and aerial surveys show that red-crowned cranes breed in Heilongjiang, Jilin, and Liaoning Provinces, but most of them breed in Heilongjiang Province. They mainly nest in the following eight areas in China (see Table 1 and Figure 1).

#### Honghe Nature Reserve and the Lower Reaches of the Amur River

This area is a delta at the confluence of Songhua River, Amur River and Ussuri River, at the northeastern corner of China. Here is the lower part of the Sanjiang Plain. The lowest place is only 35 m above sea level. The flooding rivers form vast marshlands and reed swamps. In May 1984, we observed 51 red-crowned cranes.

#### Qixing River Basin

The river is a branch of the upper Naoli River; on both sides of the Qixing River, large areas of marshlands and reed swamps cover 96,000 ha. In May 1984, the largest breeding group of red-crowned cranes in China was found here, numbering 176 birds.

#### Lower Reaches of Dulu River

This river is a north branch of the Songhua River. It originates from Xiaoxingan Mountain and flows for 245 km. The lower reaches have smooth terrain and large areas of reed swamps occupying about 16,000 ha. We observed 23 red-crowned cranes near the Dulu River in May 1984, including four pairs with eggs.

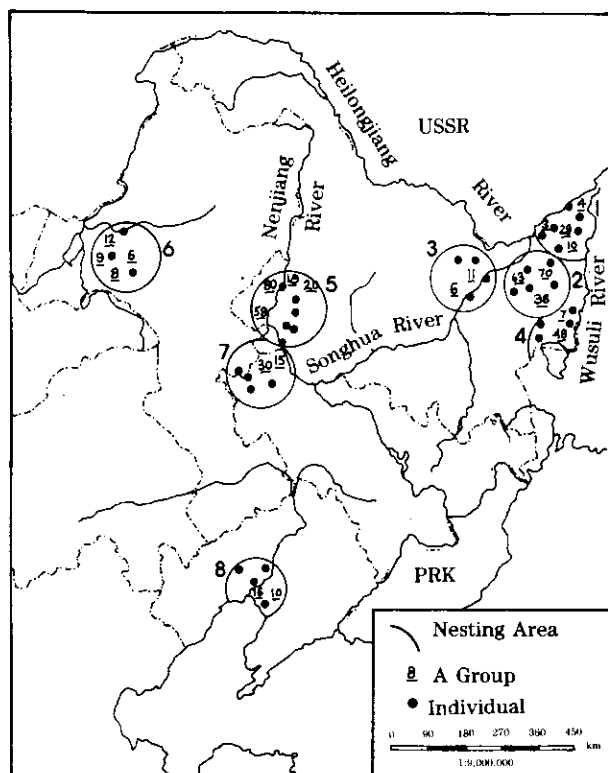


Figure 1. Distribution and numbers of red-crowned cranes on the breeding grounds. Locations #1-8 are the same as in Table 1.

Area	Date of survey	Census method	Number of cranes	Administrative division
1. Honghe Nature Reserve	1984.5	Aerial	51	Tongjiang, Raohe, Fuyuan Heilongjiang Province
2. Qixing River	1984.5	Aerial	176	Jixian, Fujin, Baoqing Heilongjiang Province
3. Lower reaches of Dulu River	1984.5	Aerial	23	Luobei Heilongjiang Province
4. Xingkai Lake lowland	1984.5	Aerial	59	Mishan, Hulin Heilongjiang Province
5. Wuyuer River Basin	1981.5	Aerial	193	Qiqihar, Lindian, Taikang, Fuyu, Gannan Heilongjiang Province
6. Hui River	1986.5	Aerial	38	Xinbaerhuzuoqi Inner Mongolia
7. Lower reaches of Taoer River	1984.5	Ground	50	Taonan, Tongyu Jilin Province (Tong and Wen 1986)
8. The mouth of Shuangtaizi River	1985	Ground	30	Panjin Liaoning Province (Chen and Sun 1986)
9. Dali Lake	1985-86	Ground	3	Inner Mongolia (Feng et al., this proceedings)

Table 1. The numerical distribution of red-crowned cranes on the breeding grounds in China.

#### Xingkai Lake Lowland

This area includes the lower reaches of the Abuqin River. The river is a branch of Ussuri River. It originates from Wanda Mountain and flows for 145 km. The river course is meandering and forms a large tract of marshland. Xingkai Lake lies on the border of China and the Soviet Union with about one-third of the lake within China. There is a smaller lake on the north side of Xingkai Lake. The catchment areas are nearly 130,000 ha. Some parts of the small lake have many floating reed rafts. We observed 59 red-crowned cranes in May 1984.

#### Wuyuer River Basin

The river originates from southwestern Xiaoxingan Mountain and flows for 426 km. The drainage areas include 1,190,000 ha. The lower reaches form vast marshes. Zhalong Nature Reserve makes up the main area, about 42,000 ha. We observed 173 red-crowns here, and 20 red-crowned cranes in Nemoer River Basin.

#### Hui River Basin

This is an inland river. The water flows gently in the lower reaches, and forms vast marshlands. We found 38 red-crowned cranes here in May 1986. They are the westernmost breeding group in China.

### Xianghai Nature Reserve

The Taoer River comes from eastern Daxingan Mountain. Part of it forms Xianghai Nature Reserve, which has vast reed swamps. We observed 50 red-crowned cranes in May 1984.

### The Mouth of Shuangtaizi River

The area is part of the lower reaches of the river, where the water forms many reed swamps. Thirty red-crowned cranes were observed in 1985.

### NUMBERS ON STAGING AND WINTERING GROUNDS

The migratory routes of red-crowned cranes in China are not well known at present. According to our surveys, there are at least two migratory routes in China. The eastern migratory route is along the Ussuri River to the south, and crosses the Korean Peninsula. Some cranes stay at the seabeach of Huanghainandao Province in North Korea for wintering; other parts winter at the mouth of the Hanjiang River in South Korea. The western route is along the west coast of the Bo Sea, and crosses the peninsula of Shandong Province. Most of these birds winter on the seabeach of Jiangsu Province; some of them winter beside lakes in the lower reaches of the Yangtze River.

Many migrating cranes pass Beidaihe, on the coast of Hebei Province. The numbers of red-crowned cranes counted here are shown in Table 2.

The results of surveys indicate that red-crowned cranes only breed in northeastern regions of China, and migrate to Jiangsu, Jiangxi and Anhui Provinces to winter. The distribution of the red-crowned crane on the wintering grounds is shown in Table 3.

The locations of breeding grounds and wintering grounds of the red-crowned crane are shown in Figure 2.

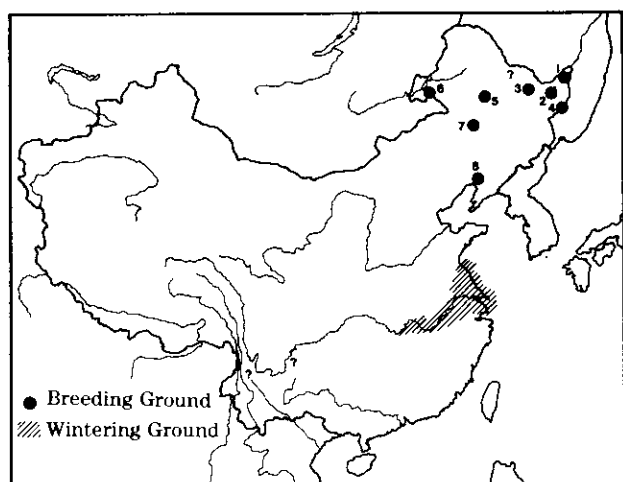


Figure 2. The distribution of the red-crowned crane in China.

### HABITAT PROTECTION

Red-crowned cranes are one of the rarest and most precious birds in China, but their habitat has suffered from destruction. Red-crowned numbers are decreasing steadily, and the distribution area is gradually shrinking because of the unceasing growth of human economic activities. The bird is in danger of extinction. Consequently, the species is classified as a first class protection bird in China. If we want to save the species, we must protect its habitats. Therefore, some nature reserves have been set up in China. By the end of 1985, six nature reserves had been established, mainly protecting red-crowned cranes and also some other waterfowl (see Table 4).

Location	Date	Season	Numbers of cranes	Source of data
Beidaihe	1985.3	spring	244	M. Williams
Beidaihe	1986.3-4	spring	191	Jin Longrong
Beidaihe	1986.10-11	autumn	497	M. Williams

Table 2. Counts of migrating red-crowned cranes

Date	Location	Number of cranes	Source of data
1983.11.20	Rudong, Jiangsu Province	6	Shi and Wu (1987)
1984	Chongming, Shanghai	12	Shi and Wu (1987)
1985.1.6	Guannan Jiangsu Province	67	Shi and Wu (1987)
1985.1.6	Guanyun Jiangsu Province	25	Shi and Wu (1987)
1985	Shijiu Lake, Dangtu Anhui Province	4	Wang and Ma (1987)
1985.10-1986.3	Yancheng Nature Reserve Jiangsu Province	575	Yu (1987)
1984.10-1985.3	Gaoyou Lake Jiangsu Province	8	Yan Anhui (1986)

Table 3. The distribution of red-crowned cranes on the wintering grounds.

Name	Location	Area (ha)	Date Established
Zhalong Nature Reserve	Qiqihar Heilongjiang Province	42,000	1979
Honghe Nature Reserve	Tongjiang Heilongjiang Province	16,333	1984
Xianghai Nature Reserve	Tongyu Jilin Province	105,469	1981
Momoge Nature Reserve	Zhenlai Jilin Province	144,000	1981
Shuangtai Nature Reserve	Panjin Liaoning Province	54,000	1985
Yancheng Seabeach Nature Reserve	Sheyang and Dafeng and three other counties Jiangsu Province	40,660	1983

**Table 4.** A list of Chinese nature reserves protecting mainly red-crowned cranes<sup>a</sup>

<sup>a</sup>Up to 31 December 1985.

#### RECOMMENDATIONS ON THE PROTECTION OF RED-CROWNED CRANES

1. We must establish a nature reserve at the mouth of the Luan River, Hebei Province, for protecting this rare bird and its migratory habitats.
2. A synchronous survey must be carried out every three years on breeding grounds and wintering grounds (including ground surveys and aerial surveys).
3. We must engage in further scientific research, and establish a Study Center for Breeding and Raising Cranes, and carry out studies of crane banding.
4. We must strengthen international cooperation and establish an International Crane Reserve at Xingkai Lake, including wetlands in both China and the Soviet Union.

#### ACKNOWLEDGMENTS

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## A WAY OF EXPEDITING THE RECOVERY OF THE RED-CROWNED CRANE

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### ABSTRACT

We experimented with methods to increase the population of red-crowned crane *Grus japonensis* at Zhalong Nature Reserve in 1985-89. A single pair can be induced to lay four eggs or more in a breeding season by taking its eggs away and hatching the additional eggs by artificial incubation. A young crane that has been hatched and raised in the wild can become accustomed to natural conditions. It can live independently in nature after it is chased away by its parents the following spring. An unpaired, adult hand-reared crane can pair and live with a wild crane under natural conditions after it is released into the wild at the beginning of the breeding season. These methods can increase the cranes' reproductive capacity and speed the recovery of the crane population.

The red-crowned crane is an endangered species. Its world wild population is estimated to be only about 1,000 (Masatomi 1985). In China several nature reserves have been established in the red-crowned crane's breeding and wintering habitats since 1979 (Ma and Li, this proceedings). The reproductive capacity of the red-crowned crane is rather low and its population increases slowly. Due to increasing land development, the species cannot regain its former numbers simply by being protected. We conducted experiments to increase the cranes' egg production and released the chicks that were produced into the wild as part of our research on ways to expedite an increase in the population of red-crowned cranes at Zhalong Nature Reserve during 1985-1989.

### STUDY SITE

Zhalong Nature Reserve is one of the important breeding grounds of the red-crowned crane (Ma and Li, this proceedings). Our study site, the headquarters of Zhalong Nature Reserve, is located on the northwest edge of the Zhalong Marsh. The pens of the captive birds lie on a small piece of upland which is surrounded by the marsh.

### METHODS

We observed these cranes in the wild with telescopes. Each of the cranes was banded with a metal ring and a color ring. Two cranes carried radio transmitters so as to be tracked more easily.

#### Allowing Captive Birds to Breed in the Wild

Thirty-four captive cranes were allowed to move freely into the marshes near their pens, since 1979 from March to October. Beginning in 1984, some of the captive birds freely chose mates, established territories, selected nest sites, built nests, laid and hatched eggs, etc. We gave these

cranes supplemental food close to the pens. Four pairs of cranes formed from these captive birds and bred in the marsh. In 1985-88, we took eggs (or chicks) from these captive pairs; also, these captive pairs would hatch eggs as part of the release experiment.

#### Increasing Egg Production

We conducted an experiment for increasing the egg laying rate with four captive pairs and two wild pairs. The cranes laid eggs recurrently when their eggs were lost or their nest had been destroyed. After the pairs laid eggs, we used the following methods to stimulate them to lay more eggs:

- 1) taking the first of the clutch after a breeding pair has laid two eggs;
- 2) taking two eggs after a breeding pair has laid two eggs;
- 3) taking the egg away as soon as a breeding pair has laid an egg; and
- 4) taking the nestlings away in the first week after the first egg has hatched.

#### Releasing Cranes into the Wild

We adopted three methods for releasing cranes into the wild.

- 1) We let our four pairs of captive cranes hatch the nestlings in the wild. People avoided the cranes as much as possible so that the chicks could be accustomed to natural conditions. When the next breeding season approached, the parents would chase their last year's chicks away.
- 2) We let hand-reared cranes pair with wild cranes and breed in the wild. Out of the 34 birds allowed to move into the marsh, three paired with wild birds.
- 3) We released the hand-reared yearling cranes to join the flock of wild-raised yearlings in the wild in spring.

RESULTS

Increasing Egg Production

Figure 1 shows the date and the number of eggs laid by the six pairs from which we experimentally took eggs. We obtained a total of 71 eggs: 22 first-clutch eggs and 49 subsequent eggs during the four breeding seasons from 6 pairs of cranes. We left 20 eggs to be incubated by the parents, and took 49 eggs and artificially incubated them; two eggs were destroyed by an animal. Out of the 71 eggs, 3 were infertile. Pairs III and IV (wild cranes) were each in only one year of the study, so there were three pairs each in the first three study years. Pair VI laid a small egg, 57.5 g in weight and 57.5 x 42.5 mm in length and width at end of their breeding season (4 June 1988). The small egg is not included above.

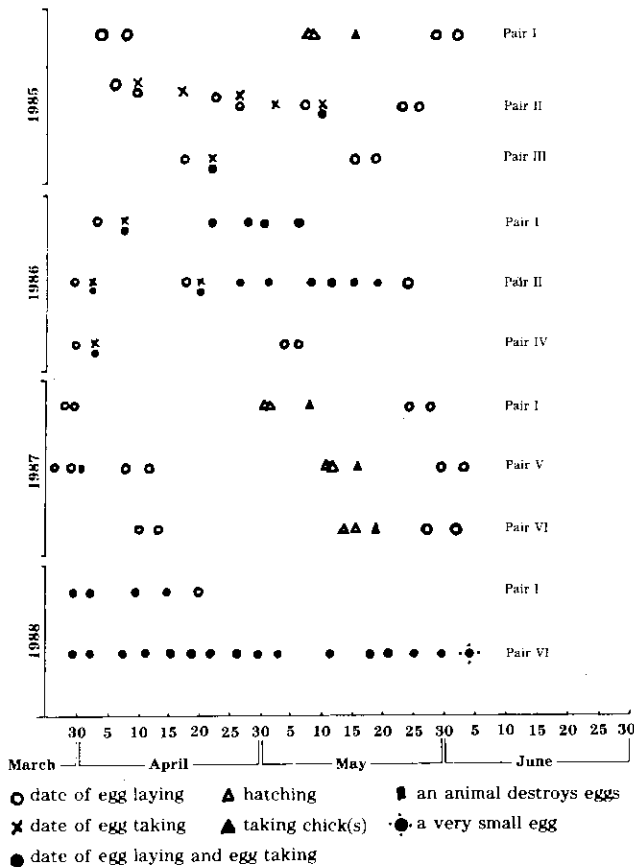


Figure 1. Records of egg laying, hatching, and taking of eggs or chicks.

Releasing Cranes into the Wild

We released 21 cranes into the wild during the five past years (see Table 1). Four of them were adults and paired with wild birds. Eleven of the cranes were raised by their captive parents in the marsh in 1985-89 and then chased away by the parents in the following spring. Six of them were hand-reared yearling cranes and joined wild yearling crane flocks in spring.

Crane #123 (last three numbers of the metal ring) paired with a wild female in September 1985. The pair often foraged, rested and roosted to the west of the headquarters of Zhalong from 9 September to December 1985 and then emigrated from Zhalong. We did not, however, receive any reports of this crane being seen elsewhere. In the middle of August 1986, crane #123 came back alone to the crane pens at Zhalong. It had lost its bands, so we banded it again. It lived in the marsh near the headquarters of Zhalong; in 1987, it paired with a captive female (pair VI) that had paired with another captive male (pair II) during 1985-86, but that male broke his leg and died.

Color Band	Metal Band	Age	Sex	Release Date	Comments
R 121	l Q00-0142	75 days	m	30 July 1985	hand-reared
	Q00-0178	1	m	17 Apr. 1987	hand-reared
	Q00-0182	1		17 Apr. 1987	hand-reared
	Q00-0187	1		17 Apr. 1987	hand-reared
	Q00-0185	1	f	21 May 1988	hand-reared
	Q00-0127	1	m	21 May 1988	hand-reared
R 123	r Q00-0124	1	m	25 Mar. 1986	raised in wild
R 120	r Q00-0115	1	m	17 Apr. 1987	raised in wild
R 122	r Q00-0161	2	m	25 Apr. 1987	raised in wild
R 126	l Q00-0167	4 months	?	23 Sep. 1987	raised in wild
R 117	l Q00-0166	1	f	10 Apr. 1988	raised in wild
R 150	l Q00-0679	1	?	7 June 1988	raised in wild
R 154	r Q00-0616	1	?	9 June 1988	raised in wild
R 155	l Q00-0688	1	m	29 Mar. 1989	raised in wild
R 156	l Q00-0620	1	m	29 Mar. 1989	raised in wild
R 157	l Q00-0621	1	f	29 Mar. 1989	raised in wild
R 158	l Q00-0606	1	f	29 Mar. 1989	raised in wild
Y 17	r Q00-0158	5	f	26 Mar. 1986	hand-reared
R 129	r Q00-0157	5	m	10 Apr. 1987	hand-reared
R 128	r Q00-0123	5	f	Sep. 1985	hand-reared
	Q00-0189	3	f	27 May 1990	raised in wild

"Y" or "R" in front of the number of the color band means yellow or red color band; "l" or "r" in front of the number of the metal band means the band is on the left or right leg; m male; f female.

Table 1. Records of crane releases at Zhalong.

Crane #158 paired with a wild male in the end of March 1986 (after she broke her pair bond with a captive male). The pair built a nest 6 km southeast of the headquarters of Zhalong and laid eggs on 19 and 21 April 1986. The pair hatched one nestling on 24 May. The family migrated southward in mid October 1986; there were no future records.

Crane #157 paired with a wild female in the last ten days of May 1986. They established a territory hut the female did not lay eggs. Crane #157 later came back alone to the crane pens of Zhalong, leaving the female at the beginning of June. At the end of June, we observed crane #157 molting. In 1987 early spring, he paired with a wild female. They raised two chicks and migrated in the fall. There were no future records. We did not see the pair in the following spring at their previous territory.

Crane #189 was raised by its parents in wild. After its parent chased it away from their territory, it moved around the pens and stayed with the captive flock. Finally, it paired with a wild bird in 1990.

In total, 20 chicks were raised in the wild by their parents during the five years. Two chicks died in the wild. One hurt its leg in fall of 1987 and was taken back into captivity. Five chicks stayed around the pens and the captive flock after their parents chased them away.

Of the six hand reared yearling chicks in Table 1, only one was purposely released. The other five mixed in the spring with chicks that had grown up in the wild. Then, in windy weather, they left the pens and went into the wild together with the wild-raised birds.

Because no follow-up study was done, we do not know much about the survivorship of the released birds. There are only a few recovery records for those birds. Crane #166 was seen in April in 1989 at Zhalong. Crane #679 and #616 were seen on 13 April 1990 at Zhalong. One of the hand-reared released chicks died 3 km away from the pens.

## DISCUSSION

### Increasing the Egg-laying Rate

Increasing the egg-laying rate of the crane is a basic method for speeding up the recovery of the crane population. Reproductive capacity is closely related to the egg-laying rate. This rate for the red-crowned crane is low naturally (Masatomi 1980; Ma 1981) and, to a great extent, limits the recovery of the population. Our experiment shows that taking eggs away can stimulate the cranes to lay more eggs in a season. By this method, we increased the laying rate from 2.0 to 6.45 eggs per reproductive period (average of the six pairs during four years,  $N = 11$ ). The reproductive capacity was tripled. The greatest number of eggs that a pair laid in a year was 15. If increased numbers of eggs can hatch and then the nestlings are fostered successfully, increasing egg productivity will be an effective method for increasing the population.

During our study, we did not try to get the largest number of eggs for every pair. Pair I laid only six eggs in 1986 spring, then stopped laying eggs by themselves in mid May. Later, we found the pair molting. That may be the reason why the female stopped laying egg in mid May. In 1988, we tried to get more eggs from pair VI. After the female laid 15 normal sized eggs, she laid a very small egg on 4 June; no more eggs were laid in that year.

### Fertility Rate and Weights of Third and Subsequent Eggs

Li and Zhang (1985) reported that the fertility rate of eggs in subsequent clutches was low, only 38.5%. Our result differs from theirs. The fertility rate of the 49 subsequent-clutch eggs was 95% and the fertility rate of the first-clutch eggs laid by each pair was 95.4% ( $N = 22$ ). This indicates that laying additional eggs did not reduce the fertility rate for the six pairs.

Would the female begin to lay eggs so small as to influence the embryonic development of the eggs as the number of eggs increased? We compared the weights of first clutch eggs with the weights of eggs of second and subsequent clutches (Table 2). The comparison showed no difference between the weights of subsequent-clutch eggs

and weights of first-clutch eggs laid by a given pair ( $t = 1.994$ ,  $df = 41$ ,  $P > 0.05$ ).

1985			
Crane Pair	Weight of Clutch (g)	Weight of Subsequent Clutches (g)	Difference
I	251.20	237.50	13.7
	229.10	217.50	11.6
II	245.20	244.30	0.90
		248.60	-3.40
		241.50	3.70
III	278.30	233.50	-9.95
		243.40	6.95
		226.55	7.35
		240.85	-6.00
	272.90	284.30	18.40
		254.50	
1986			
I	(234.48) <sup>a</sup>	253.95	-19.47
		254.75	-20.27
		227.85	6.63
		213.55	20.93
II	(253.00) <sup>a</sup>	265.75	-12.75
		263.50	-10.50
		260.10	-7.10
		241.80	11.20
		259.25	-6.25
		255.50	-2.50
		246.25	6.75
249.40	3.60		
	252.50	0.50	
1988			
I	(2.46.25) <sup>a</sup>	269.0	-22.75
		264.0	-17.75
		262.0	-15.75
VI	(268.0) <sup>a</sup>	258.75	9.25
		251.0	17.0
		248.0	20.0
		251.5	16.5
		244.5	23.5
		238.7	29.3
		250.0	18.0
		254.0	14.0
		269.0	-1
		251.5	16.5
		250.5	17.5
242.5	25.5		
250.8	17.2		

**Table 2.** Comparison of eggs of first and subsequent clutches.

<sup>a</sup>The weight in parentheses is the average for the two eggs in the first clutch. For these pairs, we compare the average weight for the first clutches with each egg of subsequent clutches. Some of the later eggs were taken before a second egg could be laid.

### Comparison of the Methods for Releasing Cranes

The result of our experiment indicated that allowing a young crane to be fostered in the wild and chased out by its parents in the wild was a better method than hand rearing. Since the young bird always lives under natural conditions, its capacity to live independently in the wild is

good. It is afraid to approach people, so the possibility of its being harmed is much less than for hand-reared cranes. The releasing time, however, is 8-9 months long and the number of young cranes that can be released into the wild by this method is limited by the number of captive pairs breeding in the marsh. During the experiment, people should avoid these cranes as much as possible and place the supplemental food far from places frequented by people. The reason the cranes released in this manner did not join wild flocks of cranes is that their parents took them to the supplemental food supply, and the chicks became accustomed to a degree of dependence on people.

Another effective method is to release hand-reared cranes into nature to pair with wild cranes. The cranes can adopt the proper breeding behavior under natural conditions, and will also migrate south with their mates for the winter. Cranes #158 and #157 are successful examples of this method. Based on our experiment, the key to applying this method successfully is the timing of the release. When a crane is released at the beginning of a breeding season, the bird can pair with a wild bird, and the pair lays eggs and perhaps raises nestlings. The pair bond will become more and more stable. This happened for crane #158 in 1986, crane #157 in 1987, and crane #189 in 1990. If the crane were released at another time, the pair might show some breeding behavior, such as dancing, unison calling, or copulating, but the pair bond would be unstable and easily disintegrate. This happened for crane #123 in 1985 and crane #157 in 1986.

Another problem with releasing hand-reared birds is that only a small portion will achieve independence in the wild. Of our 34 captive birds, only 3 paired with wild birds (only 2 of them successfully). During 5 years, we reared about 50 chicks in captivity, but only 6 of them mixed with wild flocks in the wild. The number was very small. Also the way is not safe for chicks to live successfully in the wild (see next section).

#### Transition to the Wild

Since the captive cranes have been influenced by people for all of their lives and are accustomed to the unnatural conditions provided by people, they have a reduced capacity for independent living. For example, they spend little time foraging for wild foods, do not have a strong drive to maintain a territory, do not migrate, and are not afraid to approach people. Being released and actually breeding in the wild makes these cranes recover their natural capacities and creates essential conditions for them to contact wild cranes. For example, the pairs visited the supplemental food supply every day in winter. Once they started breeding (established a territory), however, the frequency of visits was reduced. They stopped visiting the artificial food during incubation and chick raising, with the good result of keeping their chicks away from people in the wild.

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## BREEDING HABITS OF WHITE-NAPED CRANES AT ZHALONG NATURE RESERVE, CHINA

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### ABSTRACT

During 1984-88, we studied the breeding habits of the white-naped crane *Grus vipio* at Zhalong Nature Reserve. We observed their migrating and breeding behavior, including pairing, territoriality, nesting, and chick raising.

The white-naped crane is mainly distributed in the north-eastern corner of China and southeastern Siberia, USSR (Johnsgard 1983). Only limited studies on its breeding ecology have been conducted (Walkinshaw 1951 and 1973; Dymin and Pankin 1975; Yang et al. 1986; Zhu 1986; Li et al. this proceedings).

Zhalong Nature Reserve is one of the breeding grounds of the white-naped cranes, where no researchers have made detailed studies on the cranes. We conducted observations on the behavior of the white-naped cranes breeding at Zhalong Nature Reserve from 1984 through 1988. This paper summarizes our results.

### STUDY AREA

Zhalong Nature Reserve is located in the western part of Songnen Plain, a portion of the lower reaches of the Wuyuer River. Its geographic coordinates are 46°55'47"35" N, 124°00'124°30' E. This reserve is about 210,000 ha, with an elevation of less than 140 m. This region belongs to the semi-seasonal wind zone, with an obvious alternation of four seasons. Because of the flat and wide topography, the Wuyuer River floods so as to form a large marshland.

Vegetation belongs to the Mongolian flora. The main

habitats are reed marshlands, wet meadow, and grasslands (Ma and Su this proceedings). The dominant species in the marshes is reed *Phragmites communis*.

### STUDY METHODS

Activity, range and characteristics of breeding cranes near the Zhalong Nature Reserve office site were observed and recorded from the top of the office building (about 20 m high) during the breeding period.

During the migration stages, aggregating, foraging and migrating behaviors were observed from the building top.

To observe the behaviors of breeding in detail, a blind was erected near the nests. The blind was moved toward the nests gradually, as close as 70-130 m from the nests.

At the same time, we observed breeding sequence and behavior of eight captive cranes. Seven of these birds hatched from wild cranes' eggs. They were hand-reared. Another one, #5, was a chick of pair I. These eight birds were released to the wild during the breeding periods of 1986 - 89. After release, each crane chose a mate and selected a nest site on its own. For details on methods, see Xu et al. (this proceedings). Table 1 provides information on these captive birds.

No.	Birth	Sex	Courtship Date	Date paired (unison call)	Copulation	Nesting	Comments
1	May 1981	F	May 1983	October 1983	April 1986	May 1986	
2	May 1981	M	May 1983	October 1983			
3	May 1982	F	May 1984	August 1987	March 1989	April 1989	pair unstable
4	May 1981	M	June 1983				
5	June 1987	F	April 1988	August 1988			
6	May 1982	M	September 1984	August 1985	March 1987	12 April 1987	
7	May 1983	F	October 1984				
8	May 1982	M	June 1984	October 1984			

Table 1. Breeding of captive birds.

}] indicates pair

All the captive cranes and a pair of wild cranes had colored bands that allowed us to observe individuals. The pair of wild cranes was banded by the Yamashina Institute for Ornithology (Ozaki this proceedings) at Izumi, Japan on 25 January 1984; the male was observed for five years successively.

#### MIGRATION AND NUMBER

White-naped cranes come to Zhalong Reserve in late March, and leave here in early or middle October each year. Table 2 shows the earliest dates of arrival at Zhalong and the latest departure dates from 1977 to 1987.

Usually, most of the birds arrived during 25-31 March. Some of the birds are breeding to the north of Zhalong, and these may be the earliest arriving flocks. The migratory flocks often stay at Zhalong about 15-20 days. The migratory flocks depart for the north about 10 April. The breeding cranes arrived at Zhalong a little later than migratory cranes. For example, a wild breeding pair (the male had been banded) arrived on 30 March 1984, 29 March 1985, 29 March 1986, and 30 March 1987.

Migratory flocks or individuals were seen at the end of August or early September. The flocks often consisted of 6-10 birds. Sometimes, one could see larger or smaller flocks. The large flocks contained about 20 birds. They fed on grasslands or wet meadows by day, and went to marshlands for roosting before sunset.

In September, breeding pairs brought their chicks (or chick) out of their breeding territories in the daytime. The families foraged in the same areas as the migratory flocks, but they never mixed until they migrated. Most of the white-naped cranes migrated south at the end of September or early October.

The breeding population of white-naped cranes in Zhalong is about 30 birds. It is much lower than for red-crowned cranes *Grus japonensis* (Feng and Li 1985). The migratory population size is larger than the breeding

population size, but the total number is unclear. Li et al. (1987) reported the migratory flock consisted of 36-48 birds in Lindian (part of Zhalong Marsh).

#### BREEDING HABITS

##### Pairing and Courtship

The age of sexual maturity for wild cranes is still unknown. Our observations of the eight captive cranes at Zhalong Reserve indicate that the age of sexual maturity ranges from about 2-5 years. We found the first courtship behavior when the birds were one year or older. Cranes #5 and #7 showed their first courtship behavior when they were 11 and 17 months old. Most of the birds pair after sexual maturity in captivity. Crane #5 had her mate before sexual maturity (see Table 1).

During the period of pairing, the male and female often forage and rest together. On sunny and warm days, the male crane (sometimes female) dances around its mate, showing courtship. The posture of dancing is very similar to that of red-crowned cranes described by Masatomi and Kitagawa (1975), mainly composed of bowing, arching, ground digging, grass stem tossing, jumping with wing flapping, and running. The starting and stopping points of the male's running are usually close to the female. After the male stops by the female, he emits a "Hu—" in a low pitch, with bowing and arching. The female seldom responds to the dancing at first but forages or preens. If the female is satisfied with her mate, she will dance and initiate the "unison call" with the male, after the male has done his courtship shows. During the breeding period, the pair will go somewhere near their future nest site for copulation after dancing in the afternoon. If the female does not pay attention to the male's dancing, he will try again and again until he is accepted by the female.

Not all mated cranes breed in the first year in which they find their mates. Two pairs of captive cranes bred successfully 1-2 years after the time they became a pair.

	The first day seen in spring			The last day seen in fall		
	Tangtugang <sup>b</sup>	Huluxing <sup>c</sup>	headquarters <sup>d</sup>	Tangtugang <sup>b</sup>	Huluxing <sup>c</sup>	headquarters <sup>d</sup>
1977	March 24			October 12		
1978	March 29			October 17		
1979	March 23			October 7		
1980	March 26			October 4		
1981	March 20	April 1		October 5	October 27	
1982		April 3			October 25	
1983		March 20			October 23	
1984		March 26	March 23		October 28	October 3
1985		March 25	March 29		October 29	October 24
1986		March 21	March 17		October 26	October 6
1987			March 30			October 4

**Table 2.** Migration records of the white-naped crane in Zhalong.<sup>a</sup>

<sup>a</sup>Tangtugang in the northeast of Zhalong marsh, and Huluxing in the mid eastern part of the marsh belong to Lindian County; the headquarters of Zhalong Nature Reserve is on the west edge of Zhalong Marsh. <sup>b</sup>Li et al. this proceedings. <sup>c</sup>Li et al. 1987. <sup>d</sup>authors.

Those cranes having bred previously can find a new mate and breed in the same year if they lose their mate in the early breeding period. For example, the wild crane "J17" (its mate "J18" had died in South Korea in early March, 1985) was seen with a new mate at Zhalong on 29 March in the same year, and the pair laid eggs on 11 May and 14 May.

For our captive cranes released in the marsh, a crane losing its mate is able to find a new mate the same year. At Zhalong Reserve, after crane #8, the original mate of crane #7 (no record of breeding) died in May of 1985, crane #7 mated with crane #6 in August, 1985.

White-naped cranes will emit the unison call when they dance, change incubation duties (not often) or drive intruders out of their breeding territory. Conspecific neighbors will react by also unison calling. White-naped cranes do not emit the unison call in response to the red-crowned crane's unison call in the wild. In spring, however, the captive cranes of both species will call once one white-naped or red-crowned crane starts to call when it sees a migrating flock of cranes or geese near their pens.

The copulation behavior of wild white-naped cranes is the same as for the captive white-naped cranes described by Masatomi (1983). Copulation can be seen any time from 0600 to 1400 hours in the field, more often in early morning before the pair feed. The copulation site is usually near the overnight roosting spot, the nest site; sometimes it is in the feeding area during the early stage of territory establishment. Copulation behavior can be seen soon after the cranes return to the breeding ground. This behavior will last until the second egg is laid.

#### Territory Establishment and Nest Building

During the short period after cranes arrive at the breeding ground, they dig for plant roots and search for frozen or awakening insects and also fish and shrimp in shallow water; the cranes move in groups. Sometimes they go to agricultural fields where the snow has melted to pick up scattered grain. In this period, the birds move over a large range.

About a week after the families return to the breeding ground, adults chase their young cranes from the previous year out of the territory. At the same time, the range of the breeding pair is reduced greatly. Usually, the pair moves only within their breeding territory. By observing three pairs of cranes (one pair of wild, 2 pairs of captive cranes breeding in the wild, all banded) for successive years, we found that the breeding pairs will return to previous territories, but they never use old nests.

In the territory, there are two to three relatively stable foraging areas composed of reed-sedge marsh, or agricultural field. For white-naped cranes, the foraging area and nest site are clearly separated, a difference from red-crowned cranes. By day, white-naped cranes rest at the feeding site; by night, they roost at the nest site. In the foraging areas, white-naped cranes feed most of the time. The rest of their time mainly is spent preening and resting. Due to the separation between different foraging areas, cranes often fly from one area to another area. The pair seldom

stays together at the nesting area during daytime except for roosting, copulation and building the nest before incubation.

The white-naped crane is a territorial bird. A wild pair has a large breeding territory. We measured a pair's territory in three years, the size ranged from 10-12 km<sup>2</sup>. Li Peixun et al. (this proceedings) reported that the size of two breeding territories was 7 and 10.7 km<sup>2</sup> (before incubation; 4.5 and 6.9 km<sup>2</sup> during incubation) in Lindian. The size of the breeding territory may be related to the local density of the white-naped crane.

In their territory, the pair would chase away conspecific intruders. The white-naped crane's territory may overlap with territories of red-crowned cranes. Occasionally, we saw white-naped cranes fighting with red-crowned cranes, but we never saw serious conflict.

Although captive cranes bred in the wild, their breeding territories were much smaller than for wild birds. For three pairs, the captive crane territories were about 0.01-1 km<sup>2</sup>. An artificially provided food supply and lack of fear of people probably explained the small territory size. In their territories, the captive pairs chased away conspecific individuals, red-crowned cranes, and people. Another difference between captive cranes and wild birds is that the captive pairs try to protect nesting areas only during incubation and feeding areas only during chick rearing.

The habitat for nesting white-naped cranes usually is a large area of marshland interspersed with small islets or floating mounds composed of plant roots, ranging in size from several m<sup>2</sup> to 100 m<sup>2</sup>. The plant community consists mainly of sedges *Cyperus* and reeds. The nest, around which the water depth is about 20 (5-60) cm, is close to a stream or open water but with high and dense vegetation nearby, a good shelter for cranes. The nest often was built on the ground, where the plants were either cut or left uncut by people, or in the open water, or on a floating sedge-reed island. We found 16 nests: 11 on the ground (on top of the cut reeds), 3 in the open water, and 2 on floating sedge-reed islands.

Both male and female cranes work to build the nest. They start to build the nest one to two days before the female lays an egg. We do not know whether the male or female initiates nest building. The male crane maybe plays a key role in territory selection and establishment. For example, "J 17" male occupied his same territory in 1984 and 1985, even though he had different mates. The locations of the nest site and foraging areas were similar in the two years. The distance between the two nests was about 800 m.

When white-naped cranes begin to build the nest, they put their bills into water, then pull water plants by the roots out of the water. After washing the materials, they pile them to form the shape of a round table. The nest materials include leaves, stems and roots of sedges, reed stems and leaves. The plants with roots compose most of the nest materials, according to observation on sixteen nests. Especially in the bottom part of the nest, some roots are not withered because they are immersed in the water. Measurements on the sixteen nests are: diameter of the top 50 (30-75) cm; diameter of bottom 100 (80-120) cm; nest

height 20.4 (8-35) cm above water; water depth around the nest 2-45 cm.

There is a ring-shape of open water around the nest (width more than 2 m) because the cranes pull the plants out as nest material.

When the female lays the first egg, the nest is often rough and small. During incubation, the pair continues to build their nest. They often put some dry reed stems on top of the nest.

We found some nest-like structures in the nest areas. The materials of these nest-like structures were similar to regular nests but the size was smaller. Li Chunyuan et al. (this proceedings) report that every pair has one nest-like structure (they call them fake nests), but we only saw them for some pairs. According to our observation of released captive cranes, the nest-like structure resulted from disturbance when the pair was building their nest; the pair would abandon the location and start another nest elsewhere.

#### Egg Laying and Incubation

The egg laying period is from late April to mid May. The female usually lays two eggs each year. We found 22 nests with 2 eggs and 1 nest with 1 egg. The interval between laying of eggs is about 2-3 days. One end of the egg is sharper than the other end. We measured 25 eggs. The long axis was 92.8 (87.0-102.9) mm and the short axis was 59.1 (54.4-64.4) mm. The egg weight was 158.5 (130-226, N=30) g. The ground color of fresh eggs varies. Most of them are smoke gray (color 44, Smithe 1975). Some of them are maroon (color 31, Smithe 1975). Immediately after laying, the rough surface of the egg appears to have a layer of white powder. With the progress of incubation, the ground color changes to light or olive yellow, and the surface of the eggs becomes smoother. Irregular dark brown spots are distributed over the surface of the eggs and are denser on the dull end.

After the first egg is laid, male and female alternate incubating. On the first day, the rate of sitting on the nest is about 60%. Male cranes from three pairs spent 11-26 % of daytime hours incubating. A captive male, breeding in the wild, did not incubate on the first day so that its nest and egg were occupied by another captive male when the female left the nest for foraging. The former pair had to give up.

On the second day, the parents incubate the egg for 97% of the daytime. After that, they almost never leave the nest unoccupied. Sometimes, when changing places at the nest, the second parent came to the nest while the sitting parent did not leave, or even stand up. In the daytime, male and female spent similar lengths of sitting time (Table 3). Figure 1 summarizes observations of two pairs incubating. At night, the male and female incubated alternately. Several times, we observed the female sitting on the nest at 2040-2100, but when we got there in the early morning of the next day (0240-0245), we saw the male sitting on the nest. Presumably they changed incubation duties at night.

After the sun rises, the first incubation exchange occurs between 0420-0730. The length of sitting time for each parent is about 50-75 min, with a range from 15-237 min. The parents change at the nest six to eight times each day. In the morning, the pair emitted the unison call when they exchanged incubation duties. The sitting crane sometimes remained on the nest while emitting the unison call.

Usually, the sitting crane stood up to arrange the position of the eggs every 20 min. After the sitting crane would stand up, it looked around for 6-9 sec, then preened feathers on the chest and abdomen for 10-25 sec. Maybe it would look around again while arranging the eggs; it first looked at the eggs, then moved the eggs slightly with its bill. At the same time, it arranged the nest materials. Sometimes, the incubating crane did not touch the nest materials, but shook its bill as well as moved its feet and turned its body. The crane spent 1-2 min in turning the eggs and arranging nest materials when it stood up.

The eggs, lying at the center of the nest, are put between the crane's two feet. The egg's longer axis is parallel to the crane body's longer axis. If the egg's position is not as described above, the crane will re-arrange it immediately after sitting. When a crane sits down, it bends slowly, wings open half-way, and shoulder and back feathers ruffed. The chest touches the eggs first, and then the body shakes gently. After the bird sits on the nest, its neck bends, and the bill stretches 45° or lower to the ground; sometimes, the sitting crane rests with its bill hidden among the shoulder feathers or puts its bill down next to its neck. When the crane is resting, its eyes are closed but open briefly every 5-10 sec. When the crane is awake, every 3-8 sec, it stretches its neck and looks around.

		Sitting on nest		Standing on nest		Empty nest			Total observation period (min)
		time (min)	%	time (min)	%	time (min)	%	disturbance	
<b>Wild Birds</b>	male(s)	1802	46	69	1.8	80	2.0	53	3912
	female(s)	1775	45.4	133	3.4	53	1.4	53	
	total	3577	91.4	202	5.2	133	3.4	106	
<b>Captive Birds</b>	male(s)	247	19	38	2.9				1300
	female(s)	935	71.9	80	6.2				
	total	1182	90.9	118	9.1				

**Table 3.** Observations of incubation for the white-naped crane.



The sitting crane rotates its body as it arranges the egg positions. Usually, the rotation is not more than  $60^\circ$  each time. Based on observations of three pairs of cranes, the direction the head faces is random when the wind is less than force 3; at higher wind speeds, the crane will be facing the wind.

Usually after feeding, the male crane will land within 50 m of the nest, or even at the nest, when he comes back for incubating. In contrast, the female usually lands about 80-100 m from the nest. After looking around for a moment while walking, sometimes she flies again to within about 30 m of the nest, and then walks the remaining distance.

Wild breeding cranes will lower their bodies and slip away when humans approach within about 1000 m of their nests. After cranes walk out 20-40 m, they raise their heads to look around. If the human stops approaching, the cranes will wander there until people leave. If people continue to approach, the cranes walk away further, or even fly. If people force the cranes to leave, after the cranes come back they will be very careful, looking and stopping. When about 50 m from the nest, cranes will circle around the nest to make sure nobody is there.

Parents will be very reluctant to leave their nest near the time for egg hatching. On 25 May 1986, one egg of "J17" had hatched, and another egg was pipped. We came to measure and photograph them. The sitting crane, keeping the body low, slipped away from the nest and hid in grasses 30 m from the nest. When we were 10 m from the nest, the crane flew and landed 200 m from us, to distract us from the nest. Not successful, the crane returned to within 50-100 m of the nest, and emitted anxious low calling "gru, ww..."

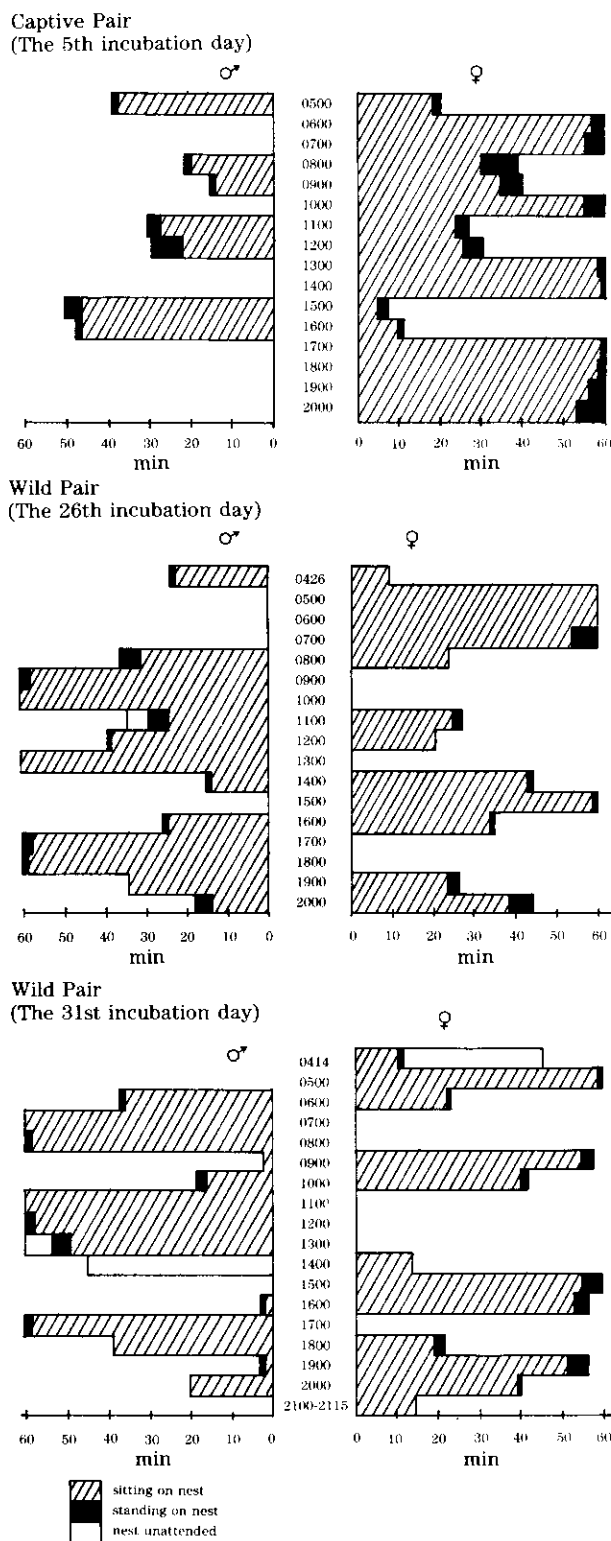
White-naped cranes will lay eggs again after losing the first clutch. For example, on 3 May 1986, the nest and egg of a captive crane were occupied by another male white-naped crane; the original male copulated with its mate next day, and the female laid an egg 19 days later. Table 4 shows re-nest records for two pairs of captive cranes breeding in the wild.

Year	Pair	Date of the first clutch	Date of the second clutch
1986	I	May 3	May 22, May 25
1987	I	April 13, April 15	June 12, June 15
1988	I	April 3, April 5	June 26, June 29
1988	II	April 4, April 9	May 23, May 25

**Table 4.** Renest records of the white-naped crane.

#### Chick Habits and Chick Raising

The incubation period is 29-31 days (12 eggs) in the wild. The chick can be heard peeping 2-3 days before the egg hatches. The chick first pecks a crack 1.3 - 1.5 cm long on the dull end of the egg. This crack develops gradually into a small hole after 6-18 hours. About 18-26 hours after the hole appears, several places on the dull end are pecked



**Figure 1.** Attendance at the nest during incubation, male and female white-naped cranes.<sup>a</sup>

<sup>a</sup>The male and female of the wild white-naped crane pair spent similar lengths of time incubating. But for captive birds, the female spent more time incubating than did the male.

open as the chick rotates in the egg. Eventually, after about 30-60 min, the chick comes out.

For a chick just hatched, the body is covered with light brown down except for the white abdomen; the base of the down is gray. The back and wing color is relatively darker. The bill is yellow with a silver gray tip and a 2 x 2 mm long white egg tooth. Tarsus and toes are deep vinaceous (color 4, Smithe 1975). Toe nails are dark gray. The measurements of 13 chicks were: weight 119.0 (86-141) g; wing 27.6 (23-32) mm; bill 23.8 (21-27) mm; and tarsus 45.0 (33-57) mm.

Once hatching, the chick tries to stand up with its tarsus, flapping its wings. After standing 5-10 sec, it has to lie on the ground, resting for a few minutes. After 3-4 hours, the chick may climb about the nest, unafraid of humans. In the meantime, it can eat insects offered by the parent. In May of 1986, "J17" adult fed its three-hour-old chick on small insects three times during the afternoon. A twenty-hour-old chick can walk around the nest. After hearing a warning from the adults, the chicks may leave the nest, swimming and hiding in the grasses. The color of a chick's down is very similar to that of withered grass. Under this camouflage, the chick is hard to find even at a very close distance.

After an egg hatches, parents still wait for the second egg, no matter what the first chick is doing, sometimes allowing the chick to get under their wings. Even after the second egg hatches, incubation behavior of adults does not disappear immediately. In May of 1986, "J17" sat on the empty egg shell for about 20 min, watching both chicks climbing about, after two eggs were hatched. Similar behavior also was seen in other cranes, the only variation being the duration of sitting on empty shell. Usually parents would eat egg shells after the chicks hatch.

When chicks are 1-3 days old, the moving range of a family is within 20 m of the nest, if without disturbance from humans. Male and female adults spend most of their time feeding chicks; occasionally one adult leaves for about 30 min.

According to observations of cranes released to the wild, even though both male and female cranes feed chicks, the male spends a little more time protecting the family. If

someone tries to approach the family, the male will quickly show threat displays to keep intruders from the family.

When chicks are 3-5 days old, the wild family will enlarge its foraging range up to a radius of 100 m of the nest. After a week, parents will take their chicks to a foraging area, one of the pair's feeding areas in their territory in the marsh. Once at the foraging area, they will spend all day feeding and resting there. Occasionally, they return to their nest for roosting.

Captive pairs moved their chicks around their nesting areas in the first week after the chicks hatched. Then they took the chicks to feeding areas, never returning to their nesting area.

Chicks can fly when they are about 80 days old. Their activity range then is not limited to the territory. Parents often bring their young cranes to an area where a non-breeding flock is feeding, or to agricultural fields. The family does not mix with the non-breeding flock.

#### CONCLUSION

Zhalong is one of the breeding grounds of white-naped cranes. White-naped cranes migrate to Zhalong in late March and early April, and they leave for the south in early and middle October each year. White-naped cranes are territorial. Without serious disturbance, the breeding cranes use the same territory as they did in the previous year. The size of each territory is about 10-12 km<sup>2</sup>. Egg laying begins in mid April. The clutch usually has two eggs. The nests look like a flat table in shape, made up of grasses and reed stems with roots. Both male and female incubate. The incubation period is about 29-31 days. Eggs are hatched during mid May and early June. Young cranes can fly when over 80 days old. After the young cranes fly, the adult cranes often take them out of their territory. Before migrating, the crane family frequently forages in the area used by non-breeding flocks, but does not mix with non-breeding individuals. Breeding cranes migrate in family units, whereas non-breeding cranes migrate in small groups of 6-10 birds. White-naped cranes mainly feed on tubers and seeds of plants, and on insects, shrimps, fish, and snails.

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## SELECTION OF NESTING SITES AND TERRITORIES BY WHITE-NAPED CRANES IN LINDIAN COUNTY, CHINA

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### ABSTRACT

This paper deals with an investigation of the territory, nesting sites and feeding habits of the white-naped crane *Grus vipio* on the breeding ground. It was carried out in April and May, 1986. Six nests were found, and the average distance between nests was 2,683 m. The average size of a territory 9 km<sup>2</sup> in the pre-incubation period, and smaller during incubation. A fecal sample analysis showed that the food of the adult was dominated by vegetable materials. During the breeding season, white-naped cranes prefer a secluded environment for their nesting site. The density of the reeds in the vicinity of the nest is moderate, and the water is shallow compared to other areas. The nearest distance from crop fields to the nesting site was about 1.5 km.

### INTRODUCTION

The selection of nesting sites and territories of white-naped cranes was studied in Lindian County in April and May, 1986. Lindian County is located in the vicinity of Qiqihar at the lower reach of the Wuyure River. Geographically, the reed swamp of Lindian County is nothing different from that of Zhalong Nature Reserve. But the water level of the swamp at Lindian County is regulated by an irrigation network. During summer and autumn, the water level is higher than at Zhalong.

### TERRITORY AND TERRITORIALITY

The survey was carried out around Langdonggang. It is the highest site in the area, with a wide view. The white-naped cranes are relatively more common here than in other places in Zhalong. Six nests were found, the average distance between nests was 2,683 m.

The territoriality was quite obvious. White-naped cranes defend their territories by vocalization, threat display, pursuit flying and walking. In order to protect their nest and eggs, cranes often exhibit their display to lure the enemy out of its territory before running away. In each territory, there were some crop fields where the cranes fed. We also found white-naped cranes often feeding together with red-crowned cranes *Grus japonensis* and showing little competition. The interspecific relationship remains almost unknown. Their territories partly overlapped.

In order to determine the size of a territory, we plotted the locations of landing spots of each bird on a map. The outmost points were then connected and an area was formed. We took measurements both before and during incubation. Two of the territories were actually measured. The result showed that these two territories during the pre-incubation period were 10.7 and 7 km<sup>2</sup> respectively and were 4.5 and 6.9 km<sup>2</sup> respectively

during incubation. That is to say the area during incubation is smaller than before (see Figure 1 and Table 1).

In 1987, we also found two nests at Langdonggang and the territories were of a similar pattern to what we noted in 1986.

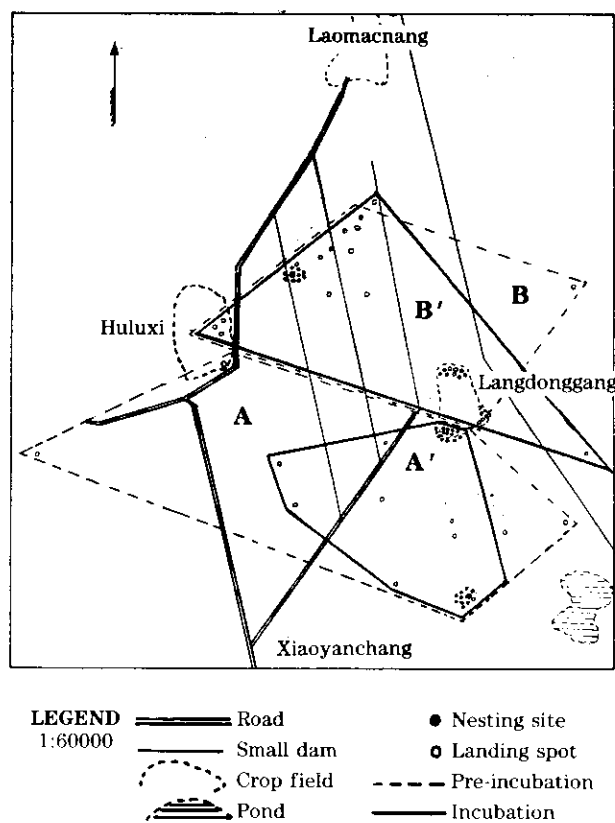


Figure 1. The size of breeding territories of white-naped cranes (before and during incubation).

Period	Pre-incubation		Incubation	
	A	B	A'	B'
Territory No.				
Dates (in April)	3-8	4-9	9-17	15-18
Observation, hr	28.5	35.5	58	49
Territory area, km <sup>2</sup>	10.7	7	4.5	6.9

**Table 1.** The size of the territories during pre-incubation and incubation periods, April 1986.

#### FOOD AND FEEDING HABITS

It is very difficult to study the food of wild cranes; we used fecal analysis. With a telescope, we watched white-naped cranes feeding in crop fields. It was quite easy to pick up their fresh droppings at times when there were only white-naped cranes present. The fecal droppings were collected during 14-23 April and 4-16 May. A total of 29 fecal samples were collected. Usually, fresh droppings are moderately soft, oblate in shape, and brown-olive or brown in color. The average weight of each piece was 3.6 g before washing. Most of the contents were vegetable matter, including wheat chaff and various kinds of seeds, leaves, small quantities of tender stems and fibrous roots (see Table 2). We didn't find any fish scales, although there were fragments of insects with a frequency of occurrence in the samples of 40-50%; the volume comprised less than 1%.

The white-naped cranes looked very alert when foraging in the fields. They held their heads up and looked around every now and then. They always dug for foods with their bills, picking the food while walking along leaving continuous furrow traces behind. This provided a sign that they had just been there.

Contents	% of occurrence in samples	
	April 14-23	May 4-16
<b>Date collected</b>		
Insect fragments, (trace)	40	50
Seed chaff, (wheat, etc.)	100	100
Monocotyledon: leaf matter	73	86
stem matter	47	71
Dicotyledon: leaf matter	47	29
stem matter	13	-
Fibrous roots	27	79

**Table 2.** Summary of fecal analysis.

#### SELECTION OF NESTING SITE

In order to understand how the white-naped cranes select their nesting sites, we took measurements of habitat factors in the vicinity of the nests during 11-17 May. We took each nesting site as a midpoint and located 12 plots: 4 plots closer to the nest, other plots disposed 15 m and 30 m away from the nest. We investigated the following habitat factors for nest sites: the depth of the water, reed density (distance between plants), the nearest distance from cultivation, PH, and the highest temperature of the water. To estimate the density of reeds, we used a system of grades 1-6 — i.e., the distance between plants was more than 10 cm, more than 8 cm, more than 6 cm, more than 4 cm, more than 2 cm, and less than 2 cm (see Table 3).

Habitat Factors	Average
Water depth (cm)	
around the nest	9.9
15 m away from the nest	14
30 m away from the nest	17.2
Reeds density (distance between plants, cm)	
around the nest	6(4-10)
15 m away from the nest	4(2-6)
30 m away from the nest	5(4-7)
The nearest distance from crop field (km)	2.8(1.5-3.5)
PH	7.9
The highest temperature of water (C°)	13.5

**Table 3.** Measurements of habitat factors at six nesting sites (during incubation).

Table 3 shows that, during the breeding season, white-naped cranes preferred a secluded environment for nesting sites. The density of reeds in the vicinity of the nest was moderate. The distance between plants was about 5 cm. The depth of the swamp around the nest was shallower compared to that in areas farther from the nest. The average water depth was about 14 cm by the nest. The nearest distance from crop field to the nesting site was about 1.5 km. It is possible that the irrigation system allows more cranes to settle here, by maintaining higher water levels during the summer.

## BEHAVIOR OF THE WHITE-NAPED CRANE

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### ABSTRACT

The white-naped crane *Grus vipio* is one of the rare crane species in China and is a priority for conservation at Zhalong Nature Reserve. From 1979 to 1980, we observed the habitat and breeding behavior of white-naped cranes at the major part of the reserve, Tangtugangzi, with a 40X telescope set up on the ridge of a roof. The results of our investigation follow.

### HABITAT

The Zhalong Nature Reserve is at the lower reach of the Wuyure River on the Songnen Plain in the west of Heilongjiang Province. The area is flat. The major river is the Wuyure River which originates from the south slope of Xiaoxingan Ridge: when it reaches Qiqihar, the river bed is merged with reed marsh, where there are many ponds. Among the bigger ponds are East Hatai, West Hatai, and South Hatai. There are many small, nameless ponds too. The usual depth of these ponds is about 1-2 m and the deepest is 4 m. The water in the ponds is so clear that the bottom can be seen distinctly; plankton covers the surface of the ponds. Fish and shrimp provide food for cranes.

Little disturbance, sufficient food and abundant water form an ideal habitat for white-naped cranes to live and breed.

### ARRIVAL AND DEPARTURE

The wintering ground of the white-naped crane is at the middle and lower reaches of the Yangtze River and in Japan. In the summer, some white-naped cranes migrate to the Sanjiang Plain and Wuyure River Valley for breeding. We investigated the arrival and departure of white-naped cranes at Zhalong from 1977 to 1981.

Table 1 shows that the earliest spring arrival of the white-naped crane occurs during the last ten days of March every year, and the south departure is completed during the first 20 days of October. Migration takes about one month. For

example, the first group of cranes came here on 26 March 1980 and the last ones did not arrive until the end of April.

The flying pattern during migration is “—” or “^”, just like geese. The size of the group ranges from 2 to 4 birds to more than 20.

### ACTIVITIES AND FEEDING BEHAVIOR

When the white-naped cranes come from their wintering grounds, they usually appear in family groups of two or four. Single cranes can also be found on some occasions, but large flocks are rarely seen. The habitat of white-naped cranes changes often and covers a large area. During breeding season, they fly around the most while choosing their nesting sites. Once the site is chosen, habitat range will be reduced and the cranes will live within this area unless there is a disturbance. Immature cranes also choose certain territories. They often live together in small groups, but we did not find a regular pattern for the group size.

When white-naped cranes fly, they take off fast and land slowly. They flap their wings before steadily flying into the sky. When they are at a certain height, their necks and legs spread on one plane, and their wings flap slowly. When they are about to land, at 2-3 m about the ground, they put their legs down in a slight curve, quickly flap their wings two or three times, and then land on the ground. At the same time, their neck extends toward their back and their wings spread upward, forming a graceful posture.

White-naped cranes are omnivorous. When the first group of cranes arrive in spring, ice and snow have just started to melt on the fields. They eat seeds, grass roots, remaining grain, a few dead fish, and so on. After the beginning of May, the weather becomes warm. The cranes gradually turn to eat animal food such as fish, shrimp, and shell clam. They also eat some corn, wheat, plant stems, and roots. Sometimes they also eat some gravel and small ceramic pieces to help digesting.

White-naped cranes spend much time finding and eating food every day, but they can also get a good rest during this time because they consume very little energy. They maintain sharp vigilance raising their heads, looking around and escaping when disturbed.

Year	Earliest Arrival Date	Average temperature for that date	Latest departure date	Average temperature for the date
1977	24 March	-7.0°C	12 Oct.	9.9°C
1978	29 March	-9.0°C	17 Oct.	6°C
1979	23 March	-2.0°C	7 Oct.	12.7°C
1980	26 March	-2.0°C	4 Oct.	9.8°C
1981	20 March	-1.0°C	5 Oct.	9.6°C

Table 1. Migration of the white-naped crane.

## NEST BUILDING

The earliest time for white-naped cranes to build their nests is during the first 10 days of April. For example, the first nest was found at the Tangtugangzi on 15 April 1980 and the last one was found on 20 May. The nest is usually built on the surface of water where the depth of the water is 17-25 cm and surrounded with dense reeds. These conditions are required by the white-naped cranes more strictly than by the red-crowned cranes. Building of the nest is done by both male and female, but the female takes more responsibility. They usually began to build their nest on the same day when they lay eggs; usually the nest is finished 3 to 4 hours before the egg is laid. There is hardly any repairing done once the nest is built. The nest is usually situated in a low place where there is some water. The nest is shaped like a plate with slight down curve in the center. With hatching progressing, a small cavity will gradually appear at the center of the nest. White-naped cranes are not highly selective in choice of nesting materials. Reeds are used the most and combined primarily with sedges.

We didn't find the cranes carrying their nesting materials from far away places. They break reeds with their bills or grab reeds lying on the ground and pile them up together with their feet. The bottom of the nest is made of reed roots, leaves, and stems as well as some rotten plants and mud. The upper part of the nest is usually 7-8 cm above the surface of the water; some nest surfaces are closer to the water. In May, 1980, three nests were measured. They averaged 145 mm in height (ranging from 120-160 mm), 885 mm in diameter (ranging from 800-1000 mm). The water depth averaged 190 mm (ranging from 170-220 mm).

During the breeding period, the white-naped cranes have a habit of building two nests; one is real, another is fake. The distance between them is about 50-100 m. The real nest is of better quality than the fake one and is used to lay eggs. The fake nest is piled up with reed roots and mud, and used for resting or watching. Some cranes build only one nest, but these account for less than 40% of the population.

## EGG LAYING

White-naped cranes lay one clutch of eggs a year. The shell is hard and gray. The bigger end is roundish, the smaller end is relatively pointed. The bigger end is thickly covered with irregular shaped purple brown dots, the middle part is covered with uniform gray dots which gradually become rare toward the smaller end. Newly laid eggs are of a bright pink color. Then the bright color gradually fades, especially toward the end of the incubation. Six eggs were measured. They averaged 94 mm in length (ranging from 90-98 mm), 60 mm in width (ranging from 59-63 mm), and 179 g in weight (ranging from 154-205 g).

When the first egg is laid, incubation begins. The incubation period is 29 days. Both male and female share incubation, but the female takes the major part in it. During this

time, the couple stays within 300-400 m of the nest, unless there is disturbance. The couple appears inactive, moves slowly, and has a poorer appetite during this time, but always remains vigilant. When one crane is incubating, the other will be looking for food as well as guarding near the nest. During this time, they won't allow other white-naped cranes to enter their territory, but other kinds of birds can come in and out freely. Parents take turns incubating and spend most non-incubating time feeding. They usually exchange duties two or three times a day, and the timing is not regular. Their turns of incubating will be more frequent if it is a nice day and food is abundant. The interval between egg turning is often 1-2 hours, the time needed is 1-2 min. With incubation progressing, the frequency of egg turning increases gradually, and the frequency and duration of egg cooling increases too. But if the weather is bad, the frequency of egg turning and cooling will both decrease.

## CHICK REARING

Just before shell breaking, the young crane makes a small hole at one-quarter of the length near the roundish end of the egg. The hole will be gradually enlarged. After 14-15 hours, young cranes come into the world. One-third of the shell will be broken and the other part will be in one piece. At this time, the young crane can open its eyes and wriggle. Five chicks were measured. They averaged 105 g in weight (ranging from 100-110 g); the length of the bill averaged 32 mm (ranging from 30.5-33.5 mm); the length of the tarsus averaged 55 mm (ranging from 54-56 mm).

The newly hatched crane's abdomen is white, and other parts of the body are light brown. The color of the middle back and wings is a darker brown. The tip of the beak is silver-gray, and the base is light yellow. The chick has projecting nostrils, red brown strong tarsi, and dark green feet.

The white-naped crane is a precocious bird. After shell breaking, the chick can wriggle and stand up on the tarsi. After 3-4 hours, it can walk unsteadily, and will eat food after 8 hours. For the first 15 days, the chick's weight increases slowly. After 15 days, the weight increases rapidly. Right after hatching, the chick is still weak and walks with difficulty, therefore, remaining within the home range. After two months, the young crane becomes stronger and can walk very fast. The parents will then bring their young away from the nest and start a mobile life. Sometimes they will come back to the nest at night. During this period, the parents have to look after their chicks all of the time and can't leave them alone. So the family lives together for a long time and seldom becomes separated. When they sense danger, one adult crane will look after the chicks while the other attacks the intruders until they go away.

Before the chick is hatched, the parents will do some preparation, allowing the chick later to walk easily. They will stamp down grass surrounding the nest. Some parents will stamp the grass down and make a path with a width of about 30 cm. The path is usually not very straight and the length varies.



## OBSERVATIONS ON MATING BEHAVIOR OF WHITE-NAPED CRANES IN THE WILD

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### ABSTRACT

Observations on mating behavior of the white-naped cranes *Grus vipio* were made from March to April (1986, 1987) at Lindian County, Heilongjiang Province, China. The mating process was divided into three steps: I. Pre-copulation, II. Copulation, III. Post-copulation. During pre-copulation, the male never gives the loud copulatory call that is always heard in the red-crowned crane *Grus japonensis*. The female's "wing-spreading" and the male's "bill raising" are the key postures to solicit copulation. During the post-copulation, the male and the female raise their heads gracefully and extend their necks beyond the vertical over their backs. This is especially exaggerated in the male. Our observations in the field compare well with those of Masatomi (1983) of captive birds. There was more dancing, however, in the wild.

### INTRODUCTION

In the past 20 years, the behavior, especially the breeding behavior, of various crane species such as the blue crane *Anthropoides paradisea*, common crane *Grus grus*, red-crowned crane, sandhill crane *G. canadensis*, and Siberian crane *G. leucogeranus* has been studied widely (Johnsgard 1983). Van Ee (1966), Sauey (1976), Tacha (1981), and Masatomi (1983) have observed the mating behavior of six crane species (red-crowned, white-naped, sarus *G. antigone*, sandhill, blue, and gray crowned *Balearica regulorum* in captivity.

In order to study the mating behavior of white-naped cranes in the wild, we observed and recorded such behaviors of four pairs of wild white-naped cranes from March to April (1986, 1987) in Lindian County, Heilongjiang Province, China. This paper is the preliminary description and analysis of these records. The behaviors were usually watched through 8X or 40X binoculars and were recorded by camera with 40X telephoto lens, occasionally by sketch.

the lower reaches of the Wuyur River, white-naped cranes started their mating period in late March before laying eggs.

The average temperature in that area is -2.7°C in March and 4.8°C in April, and the ground is still covered with ice and snow during that period. The mating behavior was generally observed in the morning (0600-0800) or in the afternoon (1500-1700) when the cranes were foraging. The place where mating behavior took place was relatively fixed. They often foraged in a fixed area.

We found that the mating behavior of white-naped cranes consisted of various movements, but not all of these movements appeared in every process. There were only a few of the movements that were repeated every time and always looked the same. We call them pattern movements. The analysis and description of typical white-naped crane mating behavior in this paper (see Table 1) are based on the various movements shown in the photos taken in the wild.

For the sake of convenient description, we have divided the process into three steps: I. Pre-copulation, II. Copulation, III. Post-copulation.

### MATING BEHAVIOR

After arriving at the marshlands of Lindian County, on

Sequence	Movements															
	Pre-copulation					Copulation					Post-copulation					
Frequency %	a	b	c	d	G	A	C	e	E	f	F	G	a	b	c	d
Frequency %	7.13	3.57	0	100	14.28	100	100	100	100	100	100	100	0	32.14	17.85	100
Pattern Movements				+		+	+	+	+	+	+	+				+
<b>Total number of copulations observed 28</b>																

**Table 1.** Frequency of various movements during the mating process.

Capitals (A,C,E,F,G) indicate movements shown in Figure 1.

A: bill-raising; C: wing-spreading; E: cloacal contact; F: jerking up heads (warping); G: preening.  
a: chasing; b: nodding head; c: wing-shaking; d: not calling; e: mounting; f: sliding down.

I. Pre-copulation

During pre-copulation, usually the male first showed the behavior of preparing for copulation: standing still and raising its bill, with its neck obliquely extending upward (Figure 1A, "bill raising"). At the same time, the female watched the male's movement, and responded by adopting the mate's "bill-raising" posture (Figure 1B). These postures were similar to those before calling except that no loud copulatory call followed at this stage (this is unlike the red-crowned crane, in which the male always calls loudly during copulation). After "bill-raising," the female squatted slightly and spread her wings (Figure 1C). Such are the movements soliciting for copulation. During this time, the male was slowly approaching the female. At the final stage of the approach, the male started to lower its head, getting ready to jump onto the female's back (Figure 1D).

II. Copulation

When the male was behind the female, he jumped on her back. The male squatted carefully on the back of the female, flapping his wings for balance. The female lowered her body horizontally, with her wings spreading widely and her bill keeping level or downward obliquely. Then, they contacted their cloacae for about 5-10 sec (Figure 1E).

III. Post-copulation

After copulation, the male immediately slid down over the female's shoulder ("dismounting"). Both male and female bowed deeply, then jerked their heads up suddenly, and threw them back markedly, especially the male. This "warping" (Figure 1F) is a characteristic of white-naped cranes (Matsutomi 1983). Finally, preening ends the whole process (Figure 1G). Table 2 shows the typical behavior sequence of white-naped cranes during copulation.

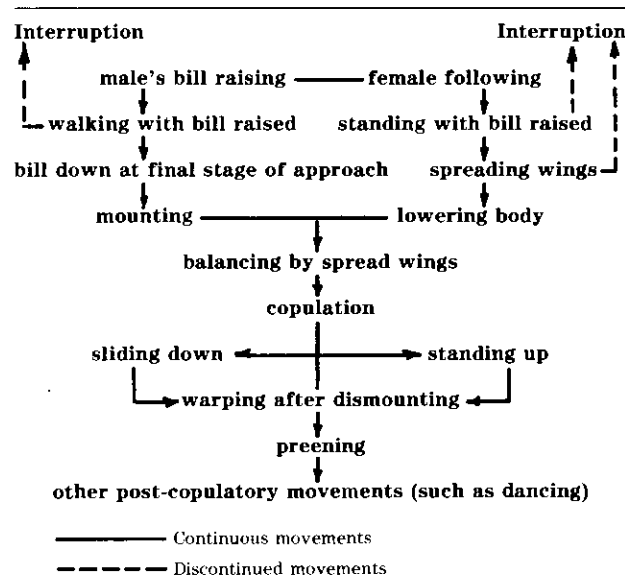


Table 2. Behavior sequence during copulation.

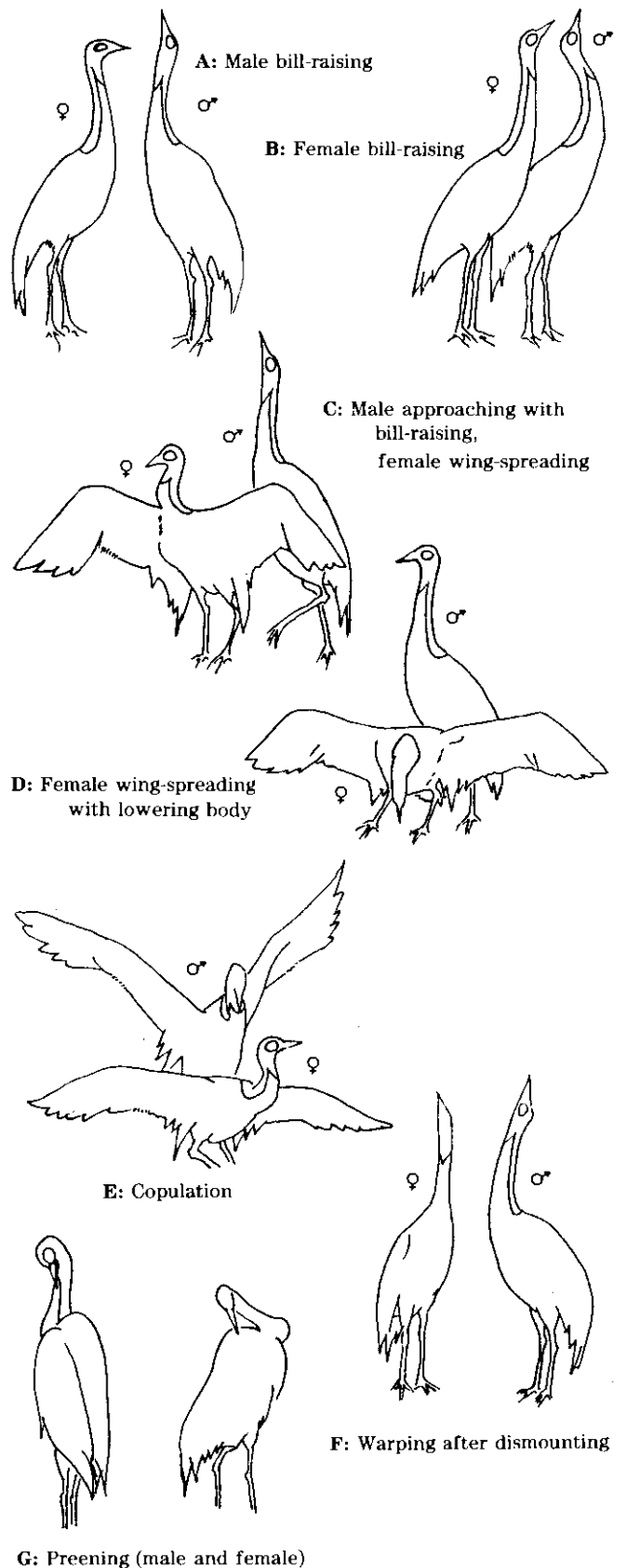


Figure 1. White-naped crane mating behavior.

## DISCUSSION

Masatomi (1983) pointed out that some modification of behavior probably occurs under artificial conditions — e.g., the pens were small (about 18 m<sup>2</sup> maximum and 17.5 x 3.6 m minimum with a shelter), and the birds' wings were clipped. Although it was possible to compare the behavior patterns of the wild and the captive red-crowned cranes, fundamental differences between them could rarely be recognized. We observed mating behavior of white-naped cranes in the wild and the result showed little difference from that of Masatomi's observation of captive birds.

During pre-copulation, we found that the female's "wing-spreading" and the male's "bill-raising" were the soliciting postures for copulation. Sometimes, however, such soliciting might fail with the male not responding to the female's "wing-spreading," or the female not responding to the male's "bill-raising." Therefore, after the soliciting posture, whether the copulation happened or not depended on the birds' response to each other. We regard the female's "wing-spreading" and the male's "bill-raising" as essential, but not necessarily adequate, conditions for copulation.

In the wild, a series of dancing behaviors often occurred during mating. The detailed description of the dancing behavior is an important task for us in the future.

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## HABITAT MANAGEMENT FOR CRANES IN ZHALONG NATURE RESERVE

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### ABSTRACT

Zhalong Nature Reserve, covering an area of 210,000 ha, is the habitat for six species of cranes. Four of the six species — red-crowned *Grus japonensis*, white-naped *G. vipio*, common *G. grus*, and demoiselle cranes *Anthropoides virgo*— breed in Zhalong. The main types of crane habitats in Zhalong are marshlands, wet meadows, and grasslands. Problems in habitat management are discussed. Improper management of water resources leads to aridity in spring and flooding during summer, seriously influencing the selection of nesting sites and breeding of cranes. Food and cover that cranes need are disturbed by people fishing, mowing reeds, and grazing livestock. The density of human population in Zhalong is still too high. Some proposals are suggested. To improve the management of the habitats of cranes, it is critical to limit the timing and range of human activities, to control effectively the water resources, to use reeds and other natural resources in a planned way, to improve the cover, to evaluate the habitats regularly and to enforce legally the above measures.

The ups and downs of wildlife populations are closely related to the quality of their habitats. To preserve a species, therefore, the first thing is to protect its living habitats. Cranes are indicator species for the wetlands, so it is very important to protect and manage the ecosystem of the wetlands, especially the living habitats of the endangered crane species. These efforts will have equivalent benefits for the protection of other species that share habitats with the cranes.

Zhalong Nature Reserve is a typical wetland reserve, located along the lower reaches of Wuyuer River in Western Shongnen Plain, 46°55' - 47°35' N, 124°00' - 124°31' E. The total area amounts to 210,000 ha, including 100,000 ha wetlands, 60,000 ha grasslands, 20,000 ha open water, 30,000 ha farmlands and forest (Su et al. 1987).

### CRANE SPECIES AND THEIR HABITATS IN ZHALONG

Six of the 15 crane species in the world can be found in Zhalong. Among them, the red-crowned, white-naped, common, and demoiselle cranes are breeding birds in this region. The number of red-crowned cranes is about 170 (Feng and Li 1985), migrating here in March and leaving in November; the number of breeding white-naped cranes is about 30, migrating here in March and leaving in October; the common and demoiselle cranes migrate here in April. Most of them fly further north until mid May, the rest of

them stay in Zhalong to breed. These cranes leave here for the south in October. The Siberian crane *Grus leucogeranus* and the hooded crane *G. monacha* are migratory birds. The length of stay for the Siberian crane in Zhalong is about 50 days, from the end of March to mid May; they number as many as 800 (Li and Li, this proceedings).

The major habitats of cranes are:

#### Grasslands

This type of habitat is located in the open lands or on the higher isolated islands with good drainage. The soil is damp and rich. The principle vegetation is the Chinese aneurolepidium *Aneurolepidium chinense*, mixed with wild weeds. The vegetation growth is very dense. The associated species include *Artemisia lanciniata*, *Sanguisorba officinalis*, *Vicia amoena*, *V. cracca*, *Lathyrus quinquenervius*, *Trifolium lupinaster*, *Hemerocallis minor*, *Glycyrrhiza walenensis*, and *Siler ciraricatum*. There are sedges *Cyperus* and *Carex* in the moist shadowed places, the basical needle grass *Stipa baicalensis* and the Siberian filifolium *Filifolium sibiricum* in the arid places. The demoiselle cranes prefer to nest and feed in this kind of habitat on the dry sites.

#### Wet Meadows

This type of habitat is usually situated in the lowlands with water all year round or seasonally. The water table underground is rather high. The soils are moist and most

of them are meadow soil. The principle cover is perennial grasses, sedges and wild weeds. The vegetational composition is rather diverse, generally of two types: meadow of *Calamagrostis epigeos* and meadow of *Puccinellia tenuiflora*. In migratory season, migratory crane flocks usually feed in this type of habitat.

#### Marshlands

There are three types of marshes in Zhalong, the Floating-sedge-reed Marsh, the Reed Marsh and the Sedge Marsh. The latter two marshes are the favorite habitats of red-crowned and white-naped cranes. The breeding sites of the red-crowned cranes are mostly reed marshes (Ma 1982; Feng and Li 1986), and the reed and sedge marshes provide the breeding sites of the white-naped cranes. The reed marshes usually are reeds *Phragmites communis* in large expanses formed of this single-species dominated community: the associated species include *Glyceria spiculosa*, *Viculana intermedia*, and *Ottelia alismoides*. The sedge marshes are located mostly in sites with water on the surface of the soil, but not so deep as in reed marshes; sedges grow well in the dry or higher sites at the wetland edge. Sedge marshes have a humus soil. The dominant species are *Carex* spp. and *Cyprus* spp. The depth of water on the soil surface usually is 5-10 cm.

#### MAIN PROBLEMS IN THE MANAGEMENT OF HABITATS

The primary landscapes in the reserve have been changed drastically by the construction of water conservancy facilities in the lower reaches of the Wuyuer River. The range of human activity has enlarged, the people's disturbance increased, and accordingly the breeding and living areas of cranes have decreased (Ma and Su 1987). In the past, this region was a natural wetland ecosystem depending upon the Wuyuer River and natural rainfall, but now it has become a wetland ecosystem depending upon the controlled water reservoir, on canals and drainage. Due to lack of comprehensive consideration by the water conservancy departments, the water utilization is not evenly distributed throughout the year. During spring drought, the Donsheng Reservoir (in the upper reaches of Zhalong's marshes) does not let water out, and the water level in the marsh is very low at this time. On the contrary, during the rainy season, large amounts of water flow from the reservoir and a canal; consequently the water level increases drastically. These water fluctuations result in the degradation of the reed vegetation and the inundation of the bird nests, threatening the crane's life and breeding. To the east of Zhalong Village, for example, there were formerly several pairs of red-crowned cranes breeding, but at present there are none because a dam was built in the marsh in 1965. The dam stops water from going to part of the area, and has changed the marshland habitats into grassland habitat.

The habitats of cranes have been seriously degraded by improper harvest. Local residents have traditional habits of fishing, cutting reeds, harvesting grass and use of pasture in the reserve area. Because of the significant economic benefits and the lack of necessary coordination among dif-

ferent departments, the harvest has become an improper mode of production that merely considers short term profits, not the future. Decreasing food and destruction of cover directly affect survival of cranes.

The breeding of cranes has also been affected directly by the continuous increase of human population and activities. There are 25 villages within Zhalong Nature Reserve, the total population is up to 24,000, and about 70-80% of production activities occur within the reserve. Though the growth of population was regulated after the establishment of the reserve in 1979, the average annual growth rate is still 3.65% (Ma and Su 1984). In addition to the natural increase, there are also new immigrants into the reserve. Spring is the breeding time for cranes and it is also the rush time for local residents' spring ploughing. Every day people and horse carts pass across the breeding territories of cranes. The vast wetlands are cut into many separated "islands" by several tens of roads. The people often walk to and from different villages. All these factors have seriously influenced the cranes' search for nest sites. In order to avoid human disturbances, cranes often wander about in marshlands and even postpone their breeding season (Su unpublished data). Some people even set up camps, go fishing, and pasture domestic animals in the breeding areas of cranes. There are many cattle grazing on the grasslands which are demoiselle cranes' breeding habitats. These activities especially affected the demoiselle crane and probably explain why only a small number of demoiselle cranes breed in this region.

#### STRATEGIES AND SUGGESTIONS ON HABITAT MANAGEMENT FOR CRANES

##### The Goal of Habitat Management for Cranes

The present situation at Zhalong Nature Reserve indicates that food, water, cover and human activities are the four major habitat factors affecting cranes. The success of crane breeding is closely related to these four factors. Therefore, the goal of habitat management for cranes should be to preserve the first three factors and to restrict the last one.

The maintenance of wetlands depends upon water. Thus water has a decisive influence on all biocommunities in the wetland ecosystem. Basic to habitat protection for cranes is to control the quantity of water flow, water levels and distribution, and to prevent pollution of the water. We therefore suggest that the Department of Water should not only consider socioeconomic benefits, but also pay more attention to ecological benefits when planning water conservancy facilities. The Department must not only consider the interests of the individual, but also the needs of the whole, especially the demands of water for crane habitat.

The diet of cranes is varied, but fish is one of the principle foods of cranes. Accordingly, the preservation of fish resources in Zhalong cannot be neglected. It is urgent for us to change the current fishing methods by which fish of all sizes are taken all year round (Ma and Su 1984). The recovery of grasslands from the cultivated highlands also is an effective way to expand the feeding range of cranes.

Among all three types of crane habitats in this region, high vegetation provides good cover for cranes to roost and breed. Future study on habitat management for cranes must determine how to preserve the vegetation in order to prevent degeneration and to promote the vegetation succession suitable for cranes (Heilongjiang Agricultural Planning Office 1982). At present, more work should be done to coordinate the relationships among agriculture, light industry and the water departments, to make local harvest and production rational. It is best, if possible, to buy the breeding areas of cranes and prohibit other uses.

In order to retain peaceful crane habitats and minimize human disturbance, a special administrative region should be established under the leadership of Qiqihar City Government. If the local residents are unable or unwilling to migrate out of the reserve, they should live under the unified administration of Zhalong Nature Reserve. In addition, there should be no more people migrating into the reserve; the natural increase of the population within the

reserve should be controlled strictly.

#### Method of Management

We should combine public education with law administration. First of all, the citizen should be taught to understand the importance of crane protection by means of the various education methods. A village public note or civil rule should also be made. Second, Zhalong Nature Reserve should promulgate regulations as soon as possible and issue notices in time.

We should set up the archival system of habitat management, through which wildlife populations and characteristics of their habitats are monitored regularly. The accumulating data will guide research and management at the reserve.

The scientific study of habitat management and environmental monitoring should be strengthened, and we should estimate the ecological pressure in order to have a scientific basis for habitat management for cranes.

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## CRANES OF JILIN PROVINCE

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### ABSTRACT

There are six crane species in Jilin Province. They are common crane *Grus grus*, hooded crane *G. monacha*, red-crowned crane *G. japonensis*, white-naped crane *G. vipio*, Siberian crane *G. leucogeranus*, and Demoiselle crane *Anthropoides virgo*. Common, hooded, and Siberian cranes are migrants, that were found at Xianghai Nature Reserve and Momoge Nature Reserve in Baicheng District in Jilin. The migratory population of Siberian crane is the largest and its stopover period is the longest of the migratory cranes. The second largest migratory population is the common crane. The hooded cranes are few and also stop a short period. Red-crowned, white-naped, and demoiselle cranes are breeding birds in Jilin Province, but most of the birds are migratory. The breeding populations of these birds are distributed in the valleys of the Houling and Nen Rivers in Baicheng District; migratory populations are distributed mostly in Baicheng and Yanbian Districts. Red-crowned cranes were also found in Jilin District. The red-crowned crane is a widely distributed bird in Jilin Province. The breeding population of the red-crowned crane, which has about 20 pairs, is the largest breeding population of crane. The second largest is the demoiselle crane. The breeding population of the white-naped crane is the smallest.

Jilin Province is in the middle part of northeast China, 40° 52' 46" 18' N and 121° 38' 131" 19' E. With many rivers and lakes, open water covers an area of 10,422 km<sup>2</sup>. The province affords suitable habitat and breeding grounds for cranes.

During 1982-83, we did a bird survey covering all of Jilin Province; during this general survey, we recorded the distribution of cranes in Jilin. In 1984-86, we studied the distribution and number of cranes in Jilin again. This paper reports the results of our surveys.

There are six crane species in Jilin Province: common, hooded, red-crowned, white-naped, Siberian, and demoiselle cranes (Figure 1).

### COMMON CRANE

Common cranes pass through Jilin. They can be seen in Baicheng District, in such places as Xianghai Nature Reserve in Tongyu County, Momoge Nature Reserve in Zhenlai County, and Yueliangpao in Daan county. In Yanbian District, they can be seen at Jingxin in Hunchun County. Most of the cranes are seen in Baicheng District, a major stopover area in the province during migration. At this time, flocks of 50-60 are usually observed, but the largest groups number as many as 200 birds. Cranes in Yanbian District are much fewer and more scattered (Fu et al. 1964); only a few birds to a dozen or so now are seen. Common cranes pass through Jilin from late March to late April, and from late September to early November (see Figure 2).

### HOODED CRANE

The hooded crane also passes through Jilin. Its distribution in the province used to cover Baicheng, Changchun, and Siping Districts (Fu et al. 1981; Zhao et al. 1984), but

in the recent years only small groups of 7-11 birds have been seen in the marshes in Tongyu, Zhenlai, and Daan Counties in Baicheng District.

### RED-CROWNED CRANE

Red-crowned cranes are widely distributed in Jilin Province: mainly in marshes along the Huolin and Nen Rivers in Baicheng District; in areas along the Songhua River in Jilin District, and in lakeside marshes in Hunchun, Wangqing, Dunhua, and Antu Counties; as well as along the Mudan and Tumen Rivers in Yanbian District (Fu et al. 1981; Zhao et al. 1984). Among these districts, Baicheng has the highest concentrations of red-crowned cranes. Groups of about 40 birds can be seen here during migration. While some birds will stay and breed in Baicheng, most will continue migrating northward. Results of our investigation in 1982 showed that some 20 pairs stayed to breed at Xianghai Nature Reserve in Baicheng District. In the past two years, the number of breeding pairs has increased slightly. Also in recent years, it has been found that red-crowned cranes build their nests at Momoge Nature Reserve. Fewer red-crowned cranes, usually no more than 20-30, are seen in Jilin and Yanbian Districts. Scattered, these are migrating birds, never seen at any other time and never observed to breed there.

In spring red-crowned cranes usually migrate through Jilin Province between late March and early May; fall migration occurs between early October and mid or late November. The breeding population stays in Jilin Province from the end of April to early October. Unlike common and Siberian cranes that migrate in large flocks, red-crowns migrate in small groups of 2 to 10 birds, which can be seen in scattered places.

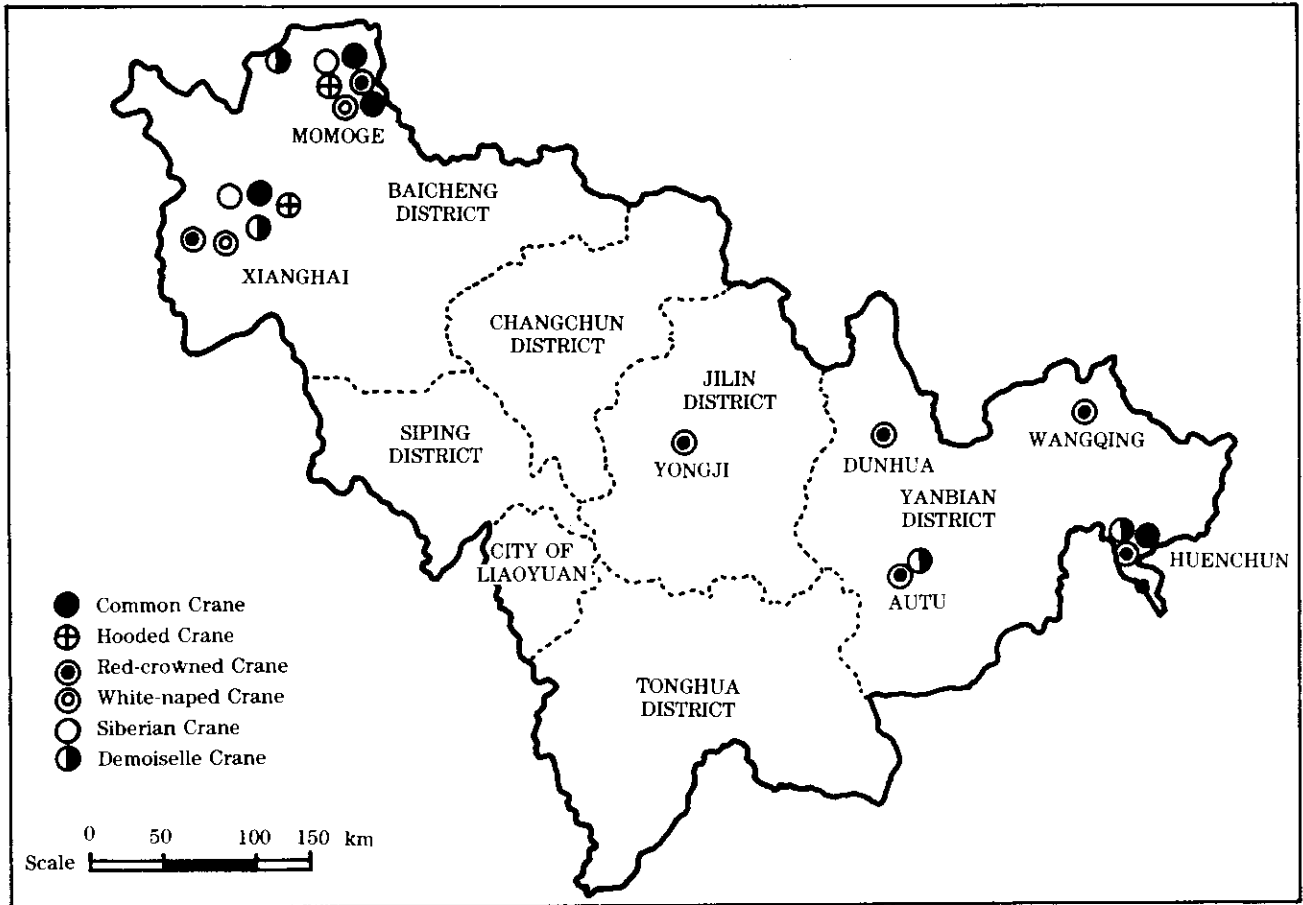


Figure 1. Crane distribution in Jilin Province.

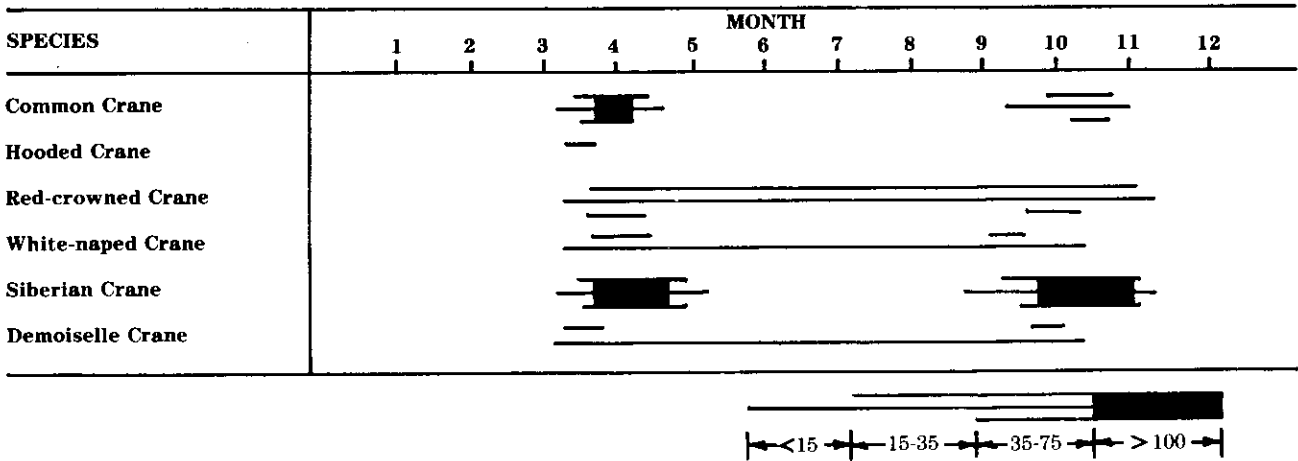


Figure 2. Monthly number of cranes in Jilin Province.<sup>a</sup>

<sup>a</sup>Numbers of cranes are indicated by lines.

#### WHITE-NAPED CRANE

White-naped cranes are seen mostly at Xianghai Nature Reserve in Tongyu County and Momoge Nature Reserve in Zhenlai County, both in Baicheng District. They also were seen in Changchun and Siping Districts in the past (Fu et al. 1981), but have scarcely been observed there since the beginning of the 1980s; they were reported by local people in these areas but not seen by us during the survey. In Jilin Province, white-naped cranes are mainly migratory birds. Small numbers breed in Xianghai, coming between the end of March and early April, and leaving between the end of October and early November. There are fewer white-naped cranes than red-crowns. In the past two years, about 30 birds have often been seen coming to Momoge Nature Reserve between late March and mid April; some individual birds have also been observed in the reserve during breeding season.

#### SIBERIAN CRANE

The Siberian cranes can only be seen in Baicheng District, at Momoge Nature Reserve in Zhenlai County and at Xianghai Nature Reserve in Tongyu County. Large numbers of this species are found in Jilin Province where migrant birds pause longer than migrants of any other species. Over 10 small groups were found in 1981 and 1982. The results of our three-year study from 1983-86 indicated that the

number of migrating Siberian cranes stopping over at the Momoge Nature Reserve usually reached about 300 both in spring and in autumn, with as many as 425 birds in the spring of 1985. During migration Siberian cranes form large flocks of 60-70 birds, consisting mostly of families. Both in spring and in autumn we have observed individual flocks of 200 birds, before take-off. Small groups of over 10 were also found in Xianghai Nature Reserve.

Siberian cranes are migrants in Jilin Province, passing through between late March and early May in spring and between mid September and early November in autumn. The usual duration of their stay in Jilin Province is about a month, although they have been observed to stay more than 50 days.

#### DEMOISELLE CRANE

Demoiselle cranes are seen only in Baicheng and Yanbian Districts. We did not find any in Siping District, but in 1982, we saw the skin of a demoiselle in a local person's house. Demoiselle cranes breed in Baicheng, only migrating through Yanbian. Momoge and Xianghai Nature Reserves in Baicheng District contain their major habitats. About 40-50 birds make up the population, slightly larger than the red-crowned crane population there. Only a few demoiselles are seen in Yanbian District: one bird in Antu County in 1980 and two birds in Hunchun County in 1983 (Zhao et al. 1985).

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## A BREEDING GROUP OF RED-CROWNED CRANES IN LIAONING PROVINCE

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### ABSTRACT

The red-crowned crane *Grus japonensis* is a summer resident in Heilongjiang and Jilin Provinces. There were no reports of its breeding in Liaoning Province. Red-crowned crane nests, eggs and young were first found in Jin, Panshan, and Dawa Counties from 1983 to 1985. Thus Liaoning Province forms the southeast border of the breeding range of the red-crowned crane. Additional birds migrate through Liaoning Province, but no red-crowned cranes have been seen here during the winter. The breeding birds number about 25 pairs. This paper reports on their nesting and habitat.

Cheng (1976) described red-crowned cranes as traveling birds in Liaoning. During the investigation of birds by the Forestry Bureau of Liaoning, Sun Shide and others on the team for south Liaoning discovered large nests and thought they might be nests of red-crowned cranes. In April 1983, the investigation team for west Liaoning obtained an eggshell of a red-crowned crane from a family in Chenjia Village at the mouth of the Daling River where local people have also collected large eggs. Accordingly, we believed that red-crowned cranes bred in Liaoning Province, but the evidence was insufficient and the breeding situation remained unclear. For this reason, the Forestry Bureau of Liaoning in 1984 requested an investigation of the breeding of red-crowned cranes, a project managed by the Biology Department of Liaoning University. From March 1984 to May 1985, the discovery of the nests, eggs, and chicks of red-crowned cranes, as well as a large breeding group, changed the traditional theory that red-crowned cranes only breed in Heilongjiang and Jilin, and moved the limit of the breeding ground 480 km or so southward.

The red-crowned crane is also called the fairy crane, and its local name is "black bottom". Local people, now over 70 years old, say that they knew red-crowned cranes here as early as their first memories. We therefore

estimate that red-crowned cranes have existed here for 60-70 years. Because people treat them as geomantic (spirit) birds, they have survived over the years.

### HABITAT

The area that red-crowned cranes inhabit lies on the coast of Liaodong Bay, which is located at 40°44'41" 26' N and 121°3'122" 30' E; it is a coastal salty wetland less than 10 m above sea level. Here, reed marshes play an important role, and mix with a saline community. There are many unvegetated salty fields along the coast, too. Daling, Raoyang, Shuangtai, Outer Liao, Big Liao, and Inner Liao Rivers all flow to the sea through this area. The major plants are *Suaeda salsa* and reeds *Phragmites communis*. Invertebrate animals include clam worms, snail clams, freshwater mussels, shrimp and crab, totalling several hundred species. Vertebrates include carp *Cyprinus carpio*, crucian carp *Carassius auratus*, mullet *Mugil soiuy*, snakefish *Ophiocephalus argus*, catfish *Parasilurus asotus* and loach *Misgurnus anguillicaudatus*, more than 90 species. There are a small number of *Rana nigromaculata* and lizards, over 200 species of birds, and more than 10

species of mice. The plant and animal resources in this area provide red-crowned cranes with good concealment and abundant food.

DISTRIBUTION AND NUMBER

The red-crowned cranes are distributed on the south end of Liaohe Plain and the north coast of Liaodong Bay (see Figure 1). The reed marsh at the mouth of Daling and Shuangtai Rivers is 2-10 m above sea level with the Dawa Township in the east and West Baqian Township, Dayou Farm, Fish Farm, and Sandaogou and Xiaohezi coastal areas of Jin County in the west. The breeding area stretches across Dawa, Panshan, and Jin Counties, belonging to four big reed farms (Nanquanhe, Dongguo, Yangjian and Dayou) with a total area of more than one million mu (over 67,000 ha). In addition, a small number of red-crowned cranes occur in Dalian, Donggou, Yengkou, Jinxi, Xingcheng and Shuizong. So far, we have not found cranes breeding here — instead, these areas appear to be an important stopover for red-crowned cranes on migration.

Twenty-four sites in five cities and counties were investigated for three years from 1983 to 1985. The results of our investigations are shown in Table 1. At the 24 survey sites, 152 red-crowned cranes have been observed, of which

maybe 50 breed in this area. The method to count their numbers is as follows. During the breeding season, the activity range of red-crowned cranes is narrow and the number more stable because red-crowns occupy territories for nesting. Therefore we visited each site repeatedly. We recorded the number of red-crowned cranes observed every time, and added all the numbers for each site together. The total was then divided by the number of visits to determine the actual number of red-crowned cranes at that particular site. Finally, we added the numbers for all sites to get the total number.

BREEDING

The cranes live in pairs at the beginning of the breeding season. We found most of the small red-crowned crane flocks then had even numbers. We also saw some non-breeding adults and immature red-crowned cranes form small mobile groups of three to five.

From the last ten days of March to the beginning of April, male and female red-crowned cranes mate and build their nest. The author found three nests each with two eggs on 14 and 15 May. One of the eggs found in the first nest on 14 May was hatched and the chick had already left the nest. Another egg had started to pip. The next day, 15 May, a

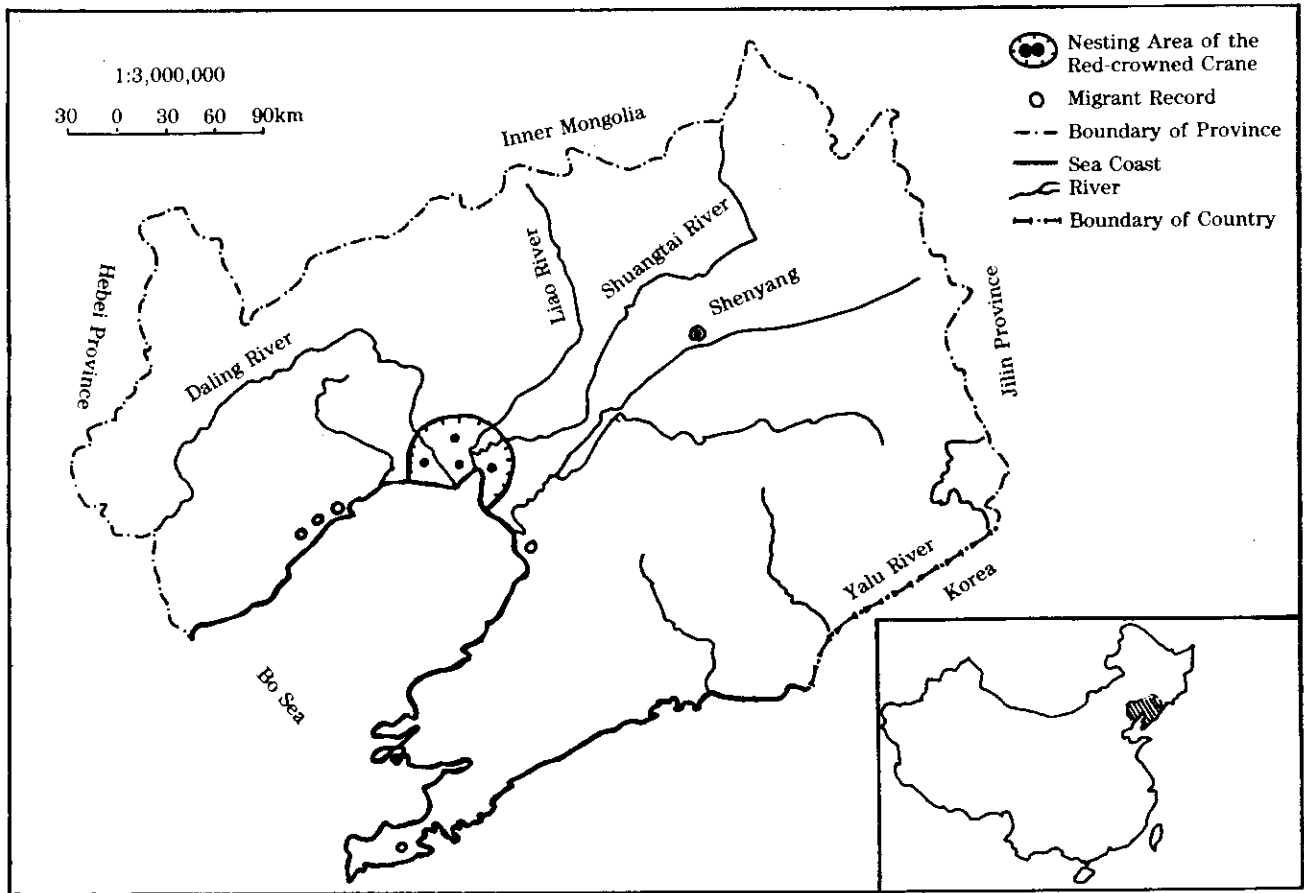


Figure 1. The breeding distribution of the red-crowned crane in Liaoning Province.

chick appeared when we revisited the site. According to past materials, the incubating period is 30-33 days (Xu et al. 1986). Therefore, we estimated that this red-crowned crane laid eggs between 10 and 13 April.

The cranes select nesting sites in reed marshes sparsely populated by people and without big barriers within 500 m. The shape of a nest is very simple, like a shallow plate. Most nests are made of dry reed stems 70 cm long. Small amounts of reed leaves and reed seed plumes in the center form a bedding. The average diameter of three nests was

133.3 cm (146, 138, 107 cm), the average diameter of the inside of the nests was 71.6 cm (70, 71, 74 cm), the average height of nests was 21.3 cm (29, 17, 17.3 cm), the average depth of the nests was 4.3 cm (4, 5, 4 cm), and the average depth of water around the nest was 10.4 cm (15, 11, 5.3 cm). The distance from the top of the nest to the water surface averaged 10.8 cm (14, 6, 12.5 cm). The distance between the second and third nests was 304 m. Five eggs weighed on average 252 g (222, 252, 274, 282 g). The eggs were elliptic in shape, the eggshell thick and strong

Date	Place	Number
11 March 1983	Lanhai Dam, Haibin Township, Xincheng County	4
10 April 1983	Nanquan River, Xibaqien, Jin County	6
16 April 1983	Wangbao Township, Shuizhong County	2
19 March 1984	Xiaodaozi, Panshan County	7
18 April 1984	Ganyugou, Zhaoquan River, Dawa County	4
21 April 1984	Lanhai Dam, Haibin Township, Xingcheng County	2
30 April 1984	Wangbao Township, Shuizhong County	2
16 May 1984	Sunjialiuzi, Shuangxiling Oil Field, Panshan County	4
20 June 1984	Ganyugou, Zhaoquan River, Dawa County	4
31 July 1984	Dayou Farm, Nanquan River, Jin County	4
20 October 1984	Baxiangang, Panshan County	4
14 December 1984	Xiaodaozi, Panshan Fish Farm, Nanquan River, Jin County and Dawa County	0
23 January 1985	Xiaodaozi, Panshan Fish Farm, Nanquan River, Dawa County, Jin County	0
29 March 1985	Hongqi Administrative District, Dongguo Reed farm, Panshan County	2
30 March 1985	Sunjialiuzi, Panshan County	4
31 March 1985	400 m southwest of Daguanzi, Shuangxiling, Panshan County	2
1 April 1985	Ganyugou, the first and second sections of Zhaoquan River, Dawa County	6
7 April 1985	Xiaodaozi, Dongguo Reed Farm, Panshan County	4
8 April 1985	Daluizi, Dongguo Reed Farm, Panshan County	4
10 April 1985	Beipigugang, Nanpigugang, Sunjialiuzi, Yugang, Panshan County	9
11 April 1985	Baxiangang, Laxiaweipu, Dongguo Reed Farm, Panshan County	5
12 April 1985	Laxiaweipu, Dongguo Reed Farm, Panshan County	2
13 April 1985	Xiaodaozi, Daluizi, Dongguo Reed Farm, Panshan County	3
14 April 1985	Sunjialiuzi, Dongguo Reed Farm, Panshan County	2
15 April 1985	Jiuhuzui, Dongguo Reed Farm, Panshan County	2
16 April 1985	Badaogou, Dongguo Reed Farm, Panshan County	2
17 April 1985	Daluizi, Dongguo Reed Farm, Panshan County	2
24 April 1985	Laxiaweipu, Dongguo Reed Farm, Panshan County	5
8 May 1985	Sunjialiuzi, Dongguo Reed Farm, Panshan County	4
9 May 1985	Louguo Qiao, Zhaoquan River, Dawa County	7
10 May 1985	Sunjialiuzi, Dongguo Reed Farm, Panshan County	3
10 May 1985	Laxiaweipu, Dongguo Reed Farm, Panshan County	4
11 May 1985	Sunjialiuzi, Nanpigugang, Panshan County	5
13 May 1985	Jiuhuzui, Dongguo Reed farm, Panshan County	4
14 May 1985	Laxiaweipu, Dongguo Reed Farm, Panshan County	2
15 May 1985	Sunjialiuzi, Dongguo Reed Farm, Panshan County	7
16 May 1985	Sunjialiuzi, Laxiaweipu, Dongguo Reed Farm, Panshan County	6
21 July 1985	Nanquan River, Jin County	4
18 September 1985	Xiaodaozi, Shangxiling, Panshan County	4
14 November 1985	the first and second sections of Zhaoquan River, Dawa County	3
21 November 1985	Zhaoquan River, Dawa County	4

**Table 1.** Observations of red-crowned cranes in Liaoning, 1983-85.

with a color of pale or light gray. The big end was speckled with rusty brown and purple gray; the small end was more sparsely speckled.

On 15 May 1985, we measured a chick in the first nest. The weight was 180 g, the height 150 mm, the wing length 31 mm, and the tarsus-metatarsus length 52 mm. On 3 June 1985, two chicks of 20 and 22 days old in the first nest were measured: weight 750 and 995 g; height 460 and 470 mm; wing length 120 and 125 mm; tarsus-metatarsus length 110 and 115 mm; and beak length 45 and 50 mm.

A nest is usually built on higher ground with a deep water area or deep trenches surrounding it. The reeds grow well wherever the water is sufficient, but the reeds are not very dense in such places where the ground is high and lacks water. If in the winter harvest season, people do not cut reeds or leave many reeds after cutting, there will be withered yellow reeds left the following spring. The red-crowned cranes choose this kind of area as their nesting site where water will not get into the nest easily, and the withered yellow reeds can be used for nest materials. Because of the deep water nearby, fishes and shrimps can winter safely, thus providing the young red-crowned cranes with food. The lush reeds in deep water can be used as concealment.

In order to determine nest locations according to the behavior of the breeding cranes, one should observe pairs or single cranes carefully. If there are only two cranes and the distance between them is over 300-500 m, it is possible that there are two nests in the area. It is best if a high power telescope can be used to observe the cranes incubating on the nests. If you find a pair of cranes or a single crane moving about in the same area for several days, it is likely that these cranes are breeding. Usually, if an incubating crane is frightened, it won't fly away or cry out; instead, it will walk away quickly and quietly from the nest. If you see this happen, search in the direction opposite to where the crane escapes. You will find the nest easily.

While looking for the young chicks from the first nest on 15 and 16 May, we found that the parents continuously called and circled 200-300 m above the nest. Newly hatched young birds stay within 10-50 m of the nest. On the second day, they can go as far as 200-300 m closely following their parents. Thus, when searching for the young, one must follow the direction of their parents. According to these methods, we estimated that there were probably 25 nests in this region.

## MIGRATION

We found that the earliest red-crowned cranes arrived in Liaoning Province on 11 March and the latest left Liaoning after 21 November. The species stays in Liaoning for seven months, totalling 255 days. In spring, summer and autumn, red-crowned cranes have only been seen breeding at the mouths of Shuangtai and Daling Rivers. Although cranes have also been found in other places, they do not breed there. These birds probably pass through Liaoning to breed in Heilongjiang and Jilin Provinces. The red-crowned cranes breeding in the northeast migrate south in autumn to winter in Yancheng and other places in Jiangsu Province. Some of them fly along the Liao and Yalu River systems and further south along the shores of the Bo Sea and the Yellow Sea. Others fly from the Yalu River over the West Korean Bay to winter in Korea.

## PROPOSAL FOR BUILDING A CRANE AND WATERFOWL RESERVE

This area is one of the largest reed marshes in the country, at once a reservoir and a polluted water purifier, an environment on which many living things, including human beings, depend for survival. But in the past 10 years, the natural environment has been seriously damaged, especially the wetlands. The area of the wetlands has shrunk quickly.

Aside from breeding red-crowned cranes, other large water birds rest here on migration: Siberian cranes *G. leucogeranus*, white-naped cranes *G. vipio*, common cranes *G. grus*, white ibis *Theskiornis melanocephala*, black storks *Ciconia nigra*, white storks *Ciconia boycianu*, and great egrets *Egretta alba*. Out of 148 species of waterfowl found in Liaoning, 87 of them occur in this area, a major part of all birds in Liaoning Province.

There are abundant animal and plant resources here, which is a treasure of mankind. But, due to the exploration for oil, well frames and drills have been erected in the reeds, power lines crisscross the reed marshes like spider nets, new roads are being built, and the water and reed ponds are polluted—all of these factors threaten the cranes and other living things in the area. Furthermore, the water in the Liao River has been polluted. If we do not protect this area, it will someday become a barren land where reeds will wither and the cranes will leave.

We must take urgent action to create a nature reserve here at the mouths of the Shuangtai and Daling Rivers.

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# PRELIMINARY STUDIES ON THE BREEDING HABITS AND DOMESTICATION OF THE DEMOISELLE CRANE

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## ABSTRACT

This paper describes the breeding habits of the demoiselle crane *Anthropoides virgo* in Xianghai and Momoge Nature Reserves in 1982-87. We also describe the hand rearing of three demoiselle crane chicks.

The demoiselle crane is the smallest of the all cranes species. There is no detailed study on its breeding ecology and domestication in China. We studied the crane in 1982-87 at Xianghai and Momoge Nature Reserves in Jilin, China. This paper reports our results.

## STUDY AREA

These two reserves are located in a flat open area. It is a dry place; the average annual rainfall is only 450 mm. The average temperatures are -21.6°C in January and 29.1°C in July. The habitats of the demoiselle crane are meadow-grassland, semi-desert-grassland, and reed marshland.

Along the Huling and Nen Rivers, there are large marshes. The dominant species is reed *Phragmites communis* in the wet areas. Accompanying species are *Juncus decipiens*, sedges *Carex* spp., and cattail *Typha* sp.

Meadow-grassland and semi-desert-grassland are drier than the marshland. The soil is poor. The vegetation in the area has a low density and is short. The dominant species is *Aneurolepidium chinese*. Other species are *Setaria viridis*, *Glycyrrhiza uralensis*, *Allium bidentatum*, *Artemisia scoparia*, *Saussurea japonica*, *Asparagus gilbus*, and *Potentilla chinensis*.

## DISTRIBUTION AND NUMBER

During 1982-86, we found the cranes mainly distributed at Xianghai Nature Reserve, with a few at Momoge Nature Reserve (see Table 1).

## BREEDING HABITS

Demoiselle cranes arrived at Xianghai and Momoge from mid to late March. First, they moved around in small flocks in all three types of habitats. After mid or late April, the flocks divided into pairs. The pairs established their breeding territories on the grassland; the pairs then remained within their territories. Their activities started at 0500 early morning, and stopped about 2000 hours.

Demoiselle cranes lay eggs from mid May to early June. We found seven nests. The nest sites are open meadow-grassland of relatively high elevation (upland). The cranes did not build actual nests. Female cranes lay their eggs

directly on unvegetated ground. The unvegetated area usually was 100 m<sup>2</sup>. A few plants grew around the unvegetated area.

All seven nests we found had two eggs. But local people reported that some clutches had one egg. The egg is oval in shape, and the shell strong and hard. The ground color of the eggs is purplish. Dark brown marks are distributed on the shell, of greater density and size at the wide end. The measurements of 14 eggs were: weight 127.6 (121.9-132.4) g, length 85.4 (83-87.5) mm, and width 55.7 (55.2-57.3) mm.

The breeding birds were very vigilant during incubation. They seldom called. The territorial bird usually stayed at a high place in the territory and looked around. They quickly flew away from the nest when an enemy approached. Watching until safe, they returned to their nest again.

A chick, five days old, was covered by down, yellow-brown on its head, dark gray-brown on its neck, back, and wings. The color of its rump was darker than other part of its body. Its abdomen was gray, its bill black. It could walk easily at this age.

Date	Location	Number of Birds
8 May 1982	Changtuozi, Xianghai Nature Reserve	5
6 May 1982	in the southwest part of Xianghai	2
20 May 1982	Changtuozi, Xianghai	3
12 June 1982	Changtuozi, Xianghai	2
8 Oct. 1982	Changtuozi, Xianghai	4
17 June 1983	Changtuozi, Xianghai	2
8 May 1984	Changtuozi, Xianghai	5
5 May 1984	Momoge Nature Reserve	5
16 May 1985	Changtuozi, Xianghai	6
11 Apr. 1986	Hujiawopeng, Momoge Nature Reserve	2
20 May 1986	Changtuozi, Xianghai	18
28 May 1987	Erbaiwan, Xianghai	6
30 May 1987	Changtuozi, Xianghai	8
24 June 1987	Ximinzhu, Xianghai	2

Table 1. Number of demoiselle cranes during 1982-87.

## DOMESTICATION

During June and July in 1982, we captured three chicks for domestication. The young birds were gentle and easy to raise.

First, we put the chicks in a basket with dry grasses inside. Then we carefully enclosed the baskets to protect against cats, dogs, or other animals, placing the baskets in a dry and quiet place, and prohibiting any stranger from visiting. We released the chicks in a yard by day when it was sunny and warm. The chicks could be put in a pen at 20 days of age. The pen was 3x4 m in size, three sides made of bricks. The other side, facing south, was open for sunlight. The pen was covered by a roof. There were dry grasses about 3 cm thick on the ground.

We divided the chicks' development period into four stages for the purpose of our study. Considering the chicks' developmental needs, we controlled the quantity and kinds of food for the chicks. For the diet of the chicks during development, see Table 2.

Diet	First Stage	Second Stage	Third Stage	Fourth Stage
meat of fish	20-30	40-100	100-200	200-300
meat of lizard	10-15	15-20	20-25	
meat of frog	15-20	20-30	30-35	30-35
grasshopper	10-20	15-30	20-25	
kernel of corn		4-8	50-100	100-150
cooked corn		5-10	20-30	30-35
corn bread		4-6	50-100	40-50
young leaves of reed		2-4	10-14	10-15
spider		2-3	6-12	15-20
insects		3-5		
root of grass		2-4		
sand		3-4		
total range per day	55-85	115-224	306-541	425-605

**Table 2.** The diet and quantity of food for the chicks (g).

During the first stage, the chick were 5-25 days old. Because the chicks were very young at this stage, we selected nutritious and easily digestible food for them. The main food was fresh, small fish; supplemental foods included meat of the lizard and snake, and grasshoppers. We cut fish into small pieces, taking away bones and hard parts. Then we put the food in front of the chicks, training the chicks to peck and eat. At first, the chicks could not eat themselves. After several attempts at training, the chicks picked food from the caretaker's hand.

During the second stage, the chicks were 26-45 days old. The chicks grew big. Their increasing weight ranged from 570 g to 1625 g. Because the chicks grew fast, they needed more food. In addition to fish, frog, snake, grasshoppers, and other animal foods, we supplied a little grain, such as corn bread, corn kernels, young leaves of reed and sedge, etc.

During the third stage, the chicks were 46-90 days old. Their weight ranged from 1625-2165 g. The food requirement increased rapidly. The average food requirement per day was about 340 g in this stage. The main food was still animal food, but with an increase in grain.

During the fourth stage, the chicks were 91-120 days old. The body size and plumage of the chicks were very close to subadult cranes, with the weight 82% of adult weight,

and length 93.9% of adult length. The food must include more than 70 g fish, a lot of grain, and also some green vegetables.

## CHICK DEVELOPMENT

Table 3 shows measurements of the weight, body size, beak, tarsus, wings, and tail. The chicks' weight increased gradually in the first stage: the average growth was 22.7 g/day. Then, the weight increased rapidly in the second stage, 52.7 g/day on average. The chicks' growth slowed in the third stage, 12.0 g/day on average. In the fourth stage, the increase was much smaller than in other stages, only 8.0 g/day on average.

The chicks' body grew quickly in the first two stages, 7.0 and 17.0 mm/day on average respectively. In the third and fourth stages, the chicks' body growth slowed down, only 2.8 and 1.7 mm/day, respectively.

The chicks' beak, tarsus, wings, and tail grew relatively quickly in the first two stages, too. The growth slowed in the third stage, and was very slow in the fourth stage.

From mid July, when the chicks were about 35 days old, their new feathers started to appear, first on the wings, shoulders, and tail. The order of appearance for wing

	First Stage	Second Stage	Third Stage	Fourth Stage
body weight range (g)	115-570	570-1625	1625-2165	2165-2397
average increase/day	22.7	52.7	12.0	8.0
length of body range (mm)	210-348.2	348.2-689	689-815.6	815.6-865.8
average increase/day	7.0	17.0	2.8	1.7
beak range (mm)	21-32	32-48	48-63.4	63.4-65
average increase/day	0.6	0.8	0.4	0.1
tarsus range (mm)	50.5-88.6	88.6-175	175-199	199-211
average increase/day	1.9	4.3	0.5	0.4
tail range (mm)	8-34.8	34.8-116	116-162	162-168
average increase/day	1.3	4.1	1.0	0.02
wing range (mm)	67-156.8	156.8-321	321-485.3	485.3-498.6
average increase/day	4.5	8.2	3.7	0.4

**Table 3.** Development of the chicks.

feathers was primaries, then secondaries, and tertiaries, from outside to inside. For the feathers on the back and abdomen, the order of appearance was from front to rear. Then the feathers grew on the neck, head, rump, and lastly under the tail.

#### CAPTIVE MANAGEMENT

When the chicks are less than ten days old, they love food very much. Be careful to control how much they eat each time. Also pay attention to the quality of food, and keep them from catching any disease.

Feeding should be at a fixed time and of a fixed quantity every day. Chicks should spend about six hours outside every day. After they are used to being outside, one can take them to walk in the field. Be careful to guard them from danger.

When it gets hot in summer, put a basin of water in their pens for bathing. Water should be changed often. In winter, put the chicks in their house, and keep the temperature about  $-15^{\circ}\text{C}$ . Put dry grasses on the ground, and keep the birds warm. Chicks should spend four hours in exercise outside daily for increasing their resistance to cold weather, helping them go through the cold winter in northeast China.



# ON THE STRUCTURE AND BEHAVIOR OF THE BREEDING POPULATION OF BLACK-NECKED CRANES IN SONGPAN MEADOW IN SICHUAN PROVINCE

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## ABSTRACT

From May to August 1986, we investigated black-necked cranes *Grus nigricollis* in Songpan Meadow, Sichuan Province, and found that the area supported an important breeding population for these birds. There were about 30 breeding pairs and about 180 non-breeding individuals. We observed one nest for eight consecutive days and nights, from hatching to ninth day, and in this paper report on behavior at the nest.

## NATURAL ENVIRONMENT AT THE BREEDING AREA

Songpan Meadow was one of the hardest sections to cover during the world-famous Long March by the Chinese Workers and Peasants' Red Army. Songpan Meadow is a vast marshy grassland extending across Songpan, Hongyuan, Zoige, and Aba Counties. Its major area is within Zoige County. Zoige County is located in the northwest part of Sichuan Province and on the northeast border of the Qinghai-Tibet Plateau, at 33°3'34"19' N and 102°8'103"36' E, with an altitude of 3,440 m above sea level.

The county is divided into two different areas by the watersheds of the Yellow and Yangtze Rivers. The Yellow River system is one of the five largest animal husbandry bases in China. Besides the Yellow River, the Black and White Rivers are in this area. In the three river basins the hills are small and low with many floodplains of sand or gravel about 30-50 km in width.

The whole topography consists of many small divides formed by intermittent ridges alternating with wide magnificent basins. In addition, we could see unusual formations of valleys, ridges, and water.

The White and Black Rivers flow from south to north, paralleling the ridges, and empty into the Yellow River. The rivers are tortuous, the water calm. Lowland marshes are well developed and are connected with the grassland, which provides the black-necked cranes with excellent habitat and breeding grounds.

The vegetation is swamp meadow with perennial hydrophyte and mesohydrophyte herbs. The dominant species belong to the sedge family: *Carex muliensis*, *Eriophorum latifolium*, and *Cobresia tibetica*. Accompanying species include *Trollius ranunculoides*, *Caltha* sp., *Pedicularis* spp., *Triglochin palustre*, and *Potentilla anserina*.

Standing water is usually 5-40 cm deep. In lakes, the water measures over 1 m. The dominant species of plants at these places are aquatic: *Polygonum amphibium*, *Utricularia vulgaris*, and *Carex mergertiana*. The accompanying species include *Triglochin maritimum*, *Creman-*

*thodium lineare*, *Halerpestes tricuspis*, and *Glyceria aquatica*.

The climate of this area is cold and moist, without clear differences in the four seasons. There is adequate rainfall, a long frost season, frequent hail, and no absolutely frost-free period.

According to the meteorological records of 1961-1980, the yearly mean temperature in this area is 0.7° C. The mean temperature in January is -10.7° C, while the lowest temperature is -33° C. The mean temperature in July is 10.7° C, with the highest temperature 24.6° C. Accumulated temperature of 0° C is 1368.4° C; accumulated temperature of 10° C is 303.1° C. The variation in temperature between day and night is 14.9° C. Annual average rainfall is 651.9 mm, with 50% falling between May and August. Solar radiation is very strong, with very bright illumination. There averages 2,403 hours of sunshine each year. Water in the rivers and lakes has a PH of 7. We measured air and water temperature during observations of the black-necked cranes at Nest No.1 (see Table 1).

Date	Air Temperature			Water Temperature <sup>a</sup>		
	0700 Hours	1400 Hours	1800 Hours	0700 Hours	1400 Hours	1800 Hours
11 June	2°c	14.5°c	17°c	5.3°c		22°c
12 June	5°c	20°c	10.2c	7°c	16°c	17°c
13 June		15°c	14°c		19°c	16°c
14 June	7.3°c		9.8°c	8.4°c	18.7°c	14.1°c
15 June	6.1°c		8.5°c	6.1°c		12°c
16 June	1°c	15.2°c		5°c	17°c	10°c
17 June	1°c	6.5°c		7.2°c	11°c	

**Table 1.** Air temperature and water temperature at Nest No. 1.

<sup>a</sup>water surface near lakeshore.

## POPULATION STRUCTURE

The population during breeding season has breeding and nonbreeding components: A) breeding birds; B) non-

breeding flocks; C) non-breeding pairs; D) families; E) single birds. Under normal conditions in the breeding area, the various groups do not disturb each other.

The latter four components make up the non-breeding population. We counted some 180 birds in the non-breeding population, accounting for 77.6 percent of the total population. Non-breeding birds account for 70.8 percent at Longbaotan, Qinghai Province (Li 1985).

#### Breeding Birds

We counted about 30 pairs in the breeding population (according to the number of nests). The nests were mainly to the east of Manrma Village in Maqu County; to the south of Moxi Village of Roigai; around the Black River Pasture; to the west of Xiaman Pasture; and to the west of Nenwa. The nests are dispersed over a vast territory.

The population averages about 0.003 pairs per km<sup>2</sup>.

#### Flocks

We observed nine flocks, with the smallest consisting of three individuals and the largest of 21. There were adults and subadults in some groups. Some flocks were made up of subadults.

#### Pairs

We counted 25 non-breeding pairs, with rather fixed zones of activity, since all had their own territories. We thought these birds were either already paired or still courting. Perhaps some of the pairs had suspended nesting that year.

#### Families

We think that family groups are very rare in breeding areas. We observed parents with one young bird near Xiaman Pasture on 24 June 1986, the first such finding.

#### Individual Birds

Only twice did we see individuals.

### BREEDING BEHAVIOR

#### Nests and Nesting Sites

Black-necked cranes select inaccessible nesting sites, where people, livestock, and wild animals rarely come. They select hummocks in the middle of a marsh where water is deep, or small islands in the lake.

Since the material they use for nests is the nearby plants, the nests are quite homogeneous. For example, material for Nest No.1 was simply *Glyceria aquatica*, while Nest No.3 was made of *Carex muliensis* and *Potamogeton pousillus*. Nest measurements are given in Table 2.

#### Egg-laying and Eggs

Observing the hatching time helps us infer when black-necked cranes lay eggs. In Roigai it was about 10 May. The color of the eggs was light greyish brown; they were

covered with irregular dark or pale brown spots.

The normal clutch size is two eggs, but Nest No.4 had only one egg. The size and weight of the eggs were similar in the three nests (Table 3).

Locality	Nest #	Height	Depth Inside	Inner Diameter	Outer Diameter
Nenwa	1	3	2	not obvious	66 × 54
Moxi	2	5	4	58 × 49	110 × 97
Black River	3	13	3	not obvious	89 × 78
		(distance from water surface)			
Maqu	4	20	2	40 × 35	90 × 70

Table 2. Measurements of nests (cm).

Egg #	Weight	Length	Width
1	192.5	99.0	60.2
2	195.0	102.1	62.3
3	200.0	104.0	66.6
4	202.0	107.5	67.8
5		98.8	60.0
Average	197.3	102.2	63.3

Table 3. Measurements of eggs (g, mm).

#### Incubation

Generally speaking, incubation is performed alternately by both parents among the world's 15 species of cranes. But for different species, or even for the same species at different times of the day or during different stages of incubation, the division of labor between male and female varies. For example, Walkinshaw (1965) found that, out of 74 brooding periods, the male sandhill crane *Grus canadensis* had a total of 41 incubating periods, with each period averaging 215 min; the female had 33 periods, with each averaging 195 min. The eggs were constantly incubated during the night. Toward the end of the incubation, the female whooping crane *Grus americana* began to spend more time on the eggs, relieving the male more frequently (Allen 1952).

We have found that with black-necked cranes incubation begins as soon as the first egg is laid. The sexes perform alternately with the female taking the greater share of the responsibility. Toward the end of incubation, the female assumes the total responsibility. We never saw the female being relieved. The male spent most of the time on the foraging ground, away from the nest.

Following hatching, we discovered the female sat on the nest at night while the male stood quietly near the nest.

#### Chicks and Chick Rearing

Typically, there is a one-day difference between the hatching of two eggs in a clutch. In our Roigai studies in 1986, we found that the first egg was hatched on 10 June and the second one at 1100 on 11 June.

The chicks were quite weak after hatching, but within a few hours they were able to stand up next to their parents and walk with faltering steps, holding their wings out to keep their balance. Sometimes the female touched her beak familiarly on the bodies of the chicks.

Simultaneously, we observed two chicks fight each other with their bills at 1210 on 11 June. They also began to accept food from their parents and one of them was seen mimicking foraging acts.

At one day after hatching, they could swim about 100 m from the nest. The older chick was larger, and moved around more than the younger one.

During chick rearing, the male left the nest at about 0520 and the female began to leave at 0600. If it was raining or cloudy, the parents would delay activities for about an hour. Non-breeding pairs started their daily activities simultaneously. But gulls, common redshanks *Tringa totanus*, and coots *Fulica atra* were not affected by the weather.

Black-necked cranes are precocious, so the time of leaving the nest is relatively unimportant for the chicks. According to Walkinshaw (1973), common crane *Grus grus* chicks are able to crawl out of the nest and hide when disturbed, after being hatched for only a few hours. Black-necked cranes and common cranes are very much alike.

As mentioned earlier, the second chick hatched on 11 June, but was already able to swim 100 m from the nest at 2000 on 12 June (when disturbed). The next day, the chicks went with their parents to the lakeshore about 200 m distant from the nest (they needed to swim 100 m to get there). The same night, the female came back to the nest with one chick, while the male roosted with the other on the northwest bank of the lake. Oddly, the parents built a new nest in the grass on the south bank of the lake at 1905 on 13 June. The depth of the surrounding water was about 15 cm. It took 1 hour 45 min to build the new nest, after which the female immediately crouched on the nest with the two chicks, while the male stood next to them.

We do not know whether the new nest was built because of disturbances. Since the water was shallow at the new nest, however, people and domestic animals could reach it easily. This nest was used for two nights by the female and one night by the male. After 16 June, they never used it again. Instead, they selected roosts without nests and brought one chick each to these places. The two roosts each night were about 100 m away from each other. Throughout the night, the adults lay face to face, calling to each other.

#### Foraging Behavior During Chick Rearing Period

Both parents fed the young birds, but the female spent more time feeding the young than did the male.

According to our observations on 17 June 1986, a high frequency of feeding occurred between 0700 and 0900. During this time, the parents fed the chicks 52 times. Thereafter the number of feedings gradually diminished as the female took over more responsibility. The male foraged alone far from the chicks and the female. Sometimes the female crouched down to rest, but the male did not.

Usually the chicks followed the female more closely than they followed the male. Sometimes they would move around, then rest in one place while they waited for food. Once the parents found suitable food, even some distance away, the parents would run very fast toward the chicks.

From the day of hatching to the eighth day, we never saw chicks foraging by themselves. We saw only two instances of pecking, and these were without purpose.

We observed two distinct ways of feeding the young: one was to place food close to their bills and let the chicks peck; the other was to put the food in front of the chicks, then peck at it a few times. It looked as if the parents were showing the chicks how to eat as well as crumbling the food to eat themselves. Even during times of high frequency feeding, the parents foraged both for themselves and for the chicks.

#### THE RELATIONSHIP BETWEEN CHICKS

Researchers both in and outside of China have reported that the survival rate of Siberian *Grus leucogeranus*, black-necked, and red-crowned *G. japonensis* cranes is very low. High mortality reportedly is often caused by fighting between chicks in the same brood, starting two days after hatching. They will not stop fighting until one dies (Lu et al. 1980; Johnsgard 1983; and Xu and Wu 1983). These cranes not only lay few eggs, but are only able to raise one chick at a time.

The authors of this paper have already taken issue with this viewpoint (Wu et al. 1986). Our observations of the two chicks in a brood from the time of hatching to the time of foraging on their own has further proved that a life and death struggle between the two chicks does not occur.

After two chicks were hatched successively on 10 and 11 June, we saw only five "fights" between the two chicks, on 11 June, but they were not serious. They were very short. Once their bills hit, one of the chicks would fall down and the fight would stop immediately. The female only intervened once, separating them with her bill. The "fight" phenomenon never appeared again after the chicks left the nest 12 June. The relationship between the two chicks was harmonious, indicating that their "fight" was intimate interaction, or simply play.

#### ENEMY-RESISTING BEHAVIOR

Earlier literature seldom mentions the enemy-resisting behavior of black-necked cranes. Although habitats of this species are sparsely populated and in out-of-the-way places, their manner of resisting enemies still needs to be studied during the breeding season.

We observed the following types of behavior.

##### Retreat

Retreating is very common during disturbance by people, especially when the birds are foraging. The adults do not appear to avoid domestic animals, not even dogs, and will remain where they are. But when chicks are present, they will retreat.

### Diversion or Distraction

This behavior occurs during nesting. When people or livestock approach the nest, the adult will stand up quickly and move away from the site. It is not an escape, but a way to distract intruders and lead them from the nest.

### Attack

If chicks are in the nest when people or predators approach, the adult birds will call out and march toward the intruder with heads and necks outstretched, wings spread slightly, bodies lowered and they wheel around the intruder. The chicks will have time to run and hide.

### Escape

Escape occurred when we tried to capture the young birds for color marking. The parents were with the two chicks as we approached. At first, the parents retreated. When we approached closer, the male threatened us several times as the female retreated continuously with the young. When we pressed on again, both parents separated from the chicks and rushed at us, to avert attention from the young birds. The chicks hid quickly, and were difficult to find.

Once when we were trying to capture cranes, a female walked up a hillside with two young birds. In order to escape rapidly, the female squatted down and let the chicks climb up on her back. To keep the chicks from falling off, she spread her wings slightly to extend the width of her back, and crouched down. Since she crawled on her tarsus, she went slowly. As the captors closed in, she zigzagged for a distance of about 8 m, then ran away, leaving the chicks behind.

### INTERSPECIFIC AND INTRASPECIFIC RELATIONS

Nest No.3 lay by a small lake which covers an area of about 0.8 km<sup>2</sup>, surrounded by hills. Beside a pair of black-necked cranes, there were ruddy shelducks *Tadorna ferruginea*, brown-headed gulls *Larus brunnicephalus*, common terns *Sterna hirundo*, great crested grebes *Podiceps cristatus* (with young birds), and coots (the two coot nests with nine eggs in one nest and 13 in the other). The distance between the two coot nests and the black-necked crane nest was 150 m and 80 m, respectively.

We did not see black-necked cranes feeding or roosting with birds of other species, but we did observe them driving ruddy shelducks out of the foraging area. The male expelled a brown-headed gull when it flew over the nest. The female uttered a "geda, geda. . ." sound at the same time (by hitting the upper and lower parts of her bill). When adult black-necked cranes were with young birds, they

never let the gulls get too close. At 2210 on 11 June, we saw a male crane stamp and hurt a common tern, tossing him into the air with his bill. The female stood by the male and called loudly.

In addition, during the breeding season black-necked cranes have distinct territories. They drive other birds of the same species out of their nesting area.

As mentioned above, there were five other species in the lake area at nest No.3. Basically they got along well together. But at 1745 on 11 June, another pair of black-necked cranes arrived. While the newcomers circled the sky, the cranes on the ground called loudly. In spite of the warning the cranes landed in the foraging area on the west bank of the lake. At first they stayed a long distance from the nest, so that the local cranes did not seem to pay attention to them. But then the newcomers started to fly toward the east bank of the lake, closer to the nest. The male at the nest flew low toward the invaders, calling loudly and skimming over them. He landed about 20 m from the new pair and proceeded to attack them twice. At last the invaders left, disappearing behind the hills. The event lasted less than an hour, but the local cranes were so upset they called nine times during the hour.

### CALLS

Black-necked cranes call in seven different situations (Li 1985). During this investigation, we noticed three kinds of calls under three different conditions.

#### Nervous and Upset Calls

Generally speaking, the calls of black-necked males and females are different. The male calls "ge-o, ge-o, ge-o. . .," while the female follows the male and calls "gege. . ., gege, gege." When the birds are especially nervous, the sounds change a little to a fast and short monosyllabic "guo, guo, guo. . ." with a higher pitch at the end. Male and female calls are the same in this situation which occurs when people and domestic animals approach them or capture their young, or when other black-neckeds encroach on their territories.

#### Threatening Call

They call "geda. . ., geda. . ., geda. . ." to approaching enemies.

#### Calling the Chicks

When the parents feed their young and demonstrate how to peck food or how to break food into smaller pieces, they call "du-du, du-du" to draw the chicks' attention.

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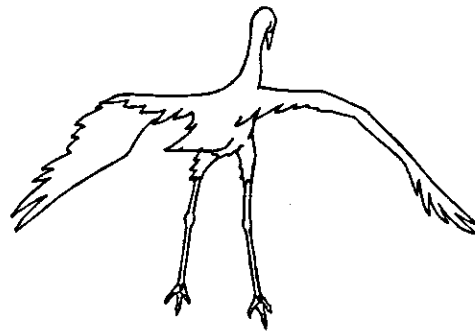
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**CHAPTER 3**  
**WINTERING AREAS**





## THE DISTRIBUTION OF CRANES IN SHANXI AND THEIR RELATION TO THE ECOLOGICAL ENVIRONMENT

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### ABSTRACT

By analyzing field-investigation data for two winters, local chronicles and other relevant materials, we conclude that common *Grus grus* and demoiselle cranes *Anthropoides virgo* occur in Shanxi Province. The statistics tell us that nowadays on the Yellow River beach there are more than 2,000 common cranes wintering every year, the largest wintering group in our country in recent years. Suitable natural and climatic conditions and large areas of peanut fields attract common cranes to winter here.

### INTRODUCTION

The author saw a small group of six to eight common cranes in the wheat fields in Yongji County in the winter of 1961 and 1962. As for other species, it has been said that there are also some red-crowned cranes *Grus japonensis*, a report not yet verified. There has been very little information on common cranes, especially their historical distribution, number, the reason for their abundance on the Yellow River beach, and the relation between their distribution and the ecological environment. To answer these questions, in winter in late 1985 and early 1987, the author made a field investigation, looked up the annals and data for the prefecture, the administrative division and the county concerned, and interviewed local hunters and elderly people. This paper reports the results.

### SPECIES, NUMBER AND RESIDENT TIME OF CRANES

According to the author's investigation, only two species of crane, common and demoiselle, have been found in Shanxi.

#### Common Crane

The author counted more than 2,000 common cranes feeding in a peanut field near the Yellow River Plantation in Hejin County in late December 1985. They flew swiftly upward when frightened. The statistics gathered by Liu Zhihu et al. (pers. comm.) in late December 1986 also include over 2,000 birds, which is the largest number of wintering common cranes found in China in recent years. Only 1,200 have been found at Poyang Lake (Ding 1985). On 1 January 1987, 5-7 cm of snow fell. The author only saw about 560 birds during 7-12 January 1987. The size of the group did not increase even when the snow melted completely on 10 January. Questions remain about whether there was a relationship between the decrease in the number and the snow, and where the disappearing cranes had gone.

#### Demoiselle Crane

On 29 May 1985, Ying County Forestry Bureau sent a demoiselle crane caught by a local peasant to the Taiyuan Zoo. It was still living in the zoo as of June 1986. On the morning of 30 October 1985, a railroad worker in Taiyuan found a demoiselle crane crouching in the grass along the railway and sent it to the zoo. There was no sign of any wound on its body. At first it refused to eat, and it died on 19 November 1985. Perhaps it had been left behind due to illness while a group passed through on their way south. These two birds caught in Ying County and Taiyuan have been the only two demoiselle cranes in the province.

#### Resident Time

In Shanxi common cranes are wintering birds. Each year they come to the Yellow River beach in mid or late October and stay there until late March or early April the next year. More than 1,000 common cranes were found still on 11 March 1986, which indicates that part of the wintering populations had already left. The rest didn't leave until 20 March. The duration of stay is about 150 days. The earliest group of wintering common cranes was found in Hejin County on 23 October 1986.

### HISTORICAL AND PRESENT DISTRIBUTION OF COMMON CRANES IN SHANXI

I found mention of cranes in various early accounts, written during the late Qing Dynasty and the early Republic of China, in the Ruicheng County local chronicles (Zhang and Xiao 1923), Ji County local chronicles (Pei 1879) and Linfen County local chronicles (Liu 1933). In "Shanxi General Chronicles," it says, "'Cilao' were historically recorded, looking like wild geese, coming or going with geese, claws being thick and bills long, wings soughing in the wind. That is quite a sight to behold." (Zeng 1892). In old days, common crane was called "Cilao," a name still

used by the local elderlies. So we know that the crane recorded in Shanxi local chronicles refers to common crane. Historically, common cranes could only be found in southern Shanxi (Figure 1). This is in agreement with the present known distribution in the southern part of the province.

The present distribution of common cranes is the Yellow River valley in the southern part of the province in Hejin, Wanrong, Linyi, Yuncheng, Yongji and Ruicheng Counties, etc., and in the northern part of the province in Suo County and Ying County, etc. (see Figure 1). Except for Hejin and Wanrong, where large numbers have been found, other places only have groups of a few to a dozen birds. According to Qu Wenhong of the Yuncheng Forest Bureau, common cranes were once seen in the 1960's here. Its main distribution in Yuncheng City was in Tanglitan, Daqu, Xizhanggeng, Beixiang, Xiyao, and Changping Village. The distribution in the other counties is mainly along the Yellow River or on the sand bars at the confluence of the Yellow and Fen Rivers. According to Liu Fuxiang (pers. comm.), common cranes were found when the Yellow River Plantation was being built in 1974. But large numbers of common cranes coming to the Yellow River beach is a recent happening.

#### ECOLOGICAL ENVIRONMENT

In recent years, common cranes are mainly in the counties along the Yellow River in southern Shanxi. They especially concentrate in Lianbe Village, Yangcun Township of Hejin County along the Yellow River beach (Figure 2). This is largely because of the natural conditions there. From Yumenkou in the north to Xiliang where the Fen River empties into the Yellow River in the south, the course of the Yellow River is broad and shallow, and the main stream is torrential. The area has a mild climate, with a yearly average temperature of 12-14°C, annual precipitation of 520-670 mm, and an annual frostfree season of 250 days. On the east bank of the Yellow River sits Hejin County; Hancheng City, of Shaanxi Province, is on the west bank. Along both banks dikes and dams have been built since liberation. The land on the east bank is open. A large number of willow and locust are planted, which have already become forest belts protecting the dikes from flood. From west of Liangbe Village to south of Cangtuo Village, human activities are sparse. Altogether the area of the floodland is about 7,200 ha, nearly half of which is sown with peanut and other crops such as wheat, beans, cotton and maize. Herbage erect milkvetch *Astragalus adsurgens* and forest protection belts cover more than ten thousand mu (666.7 ha). The remaining lands are mainly orchards and vegetable plots. The Yellow River Plantation, nursery and milk goat farm are also in this area.

Within the bank of the Yellow River is a marshland covering an area of about 533 ha and overgrown with weeds such as *Bothriochloa ischarrum*, *Suaeda glauca*, *Salsola collina*, *Conyza canadensis*, *Calamagrostis epigejos*, *Cyperus rotundus*, *Imperata cylindrica*, *Setaria viridis*, and *S. glauca*. Aquatic plants include *Typha minima*,

*Potamogeton distinctus*, and *Najas marina*. All these provide food and refuge for animals. The birds sharing the same habitats with common cranes are whooper swan *Cygnus cygnus*, swan goose *Anser cygnoides*, bean goose *A. fabalis*, spotbill duck *Anas poecilorhyncha*, common goldeneye *Bucephala clangula*, black-tailed gull *Larus crassirostris*, black stork *Ciconia nigra*, hoopoe *Upupa epops*, grey-crowned pygmy woodpecker *Dendrocopos canicapillus*, blue hill pigeon *Columba rupestris*, marsh tit *Parus palustris*, imperial eagle *Aquila heliaca*, Eurasian kestrel *Falco tinnunculus* and short-eared owl *Asio flammeus*. Mammals include *Lepus capensis*, *Cricetulus triton*, red fox *Vulpes vulpes*, wolf *Canis lupus*, *Felis bengalensis* and *Mustela sibirica*.

Dikes are built along the east and west bank of the Yellow River. Beyond the dikes there are large areas of floodland. The climate on the two sides of the river is similar, but common cranes only stay in Hejin on the east side of the river.

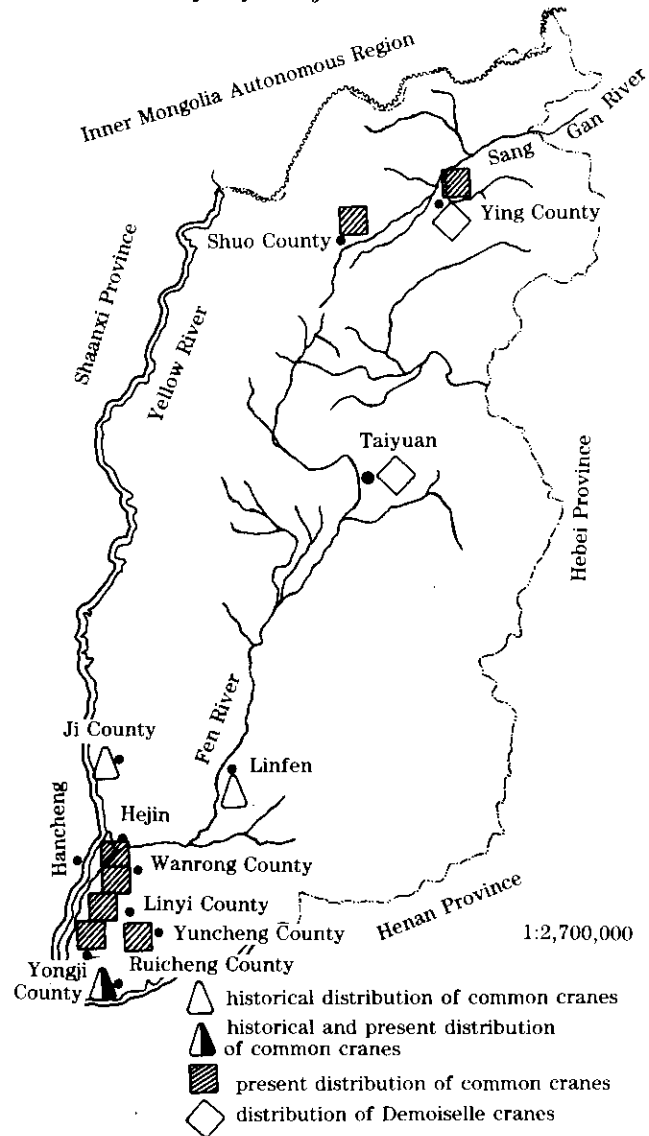


Figure 1. Distribution of cranes in Shanxi.

This is because a large part of floodland along the east dike is sown with peanut and wheat. Along the west dike, however, floodland is narrow and trees are sparse. Wheat is the main crop, with only a small amount of peanuts. In addition, there are factory and mining areas, as well as highways and railways. Every day, explosives blowing up the mountain stone can be heard. All these factors make Hancheng City on the west bank less attractive to common cranes than the east bank.

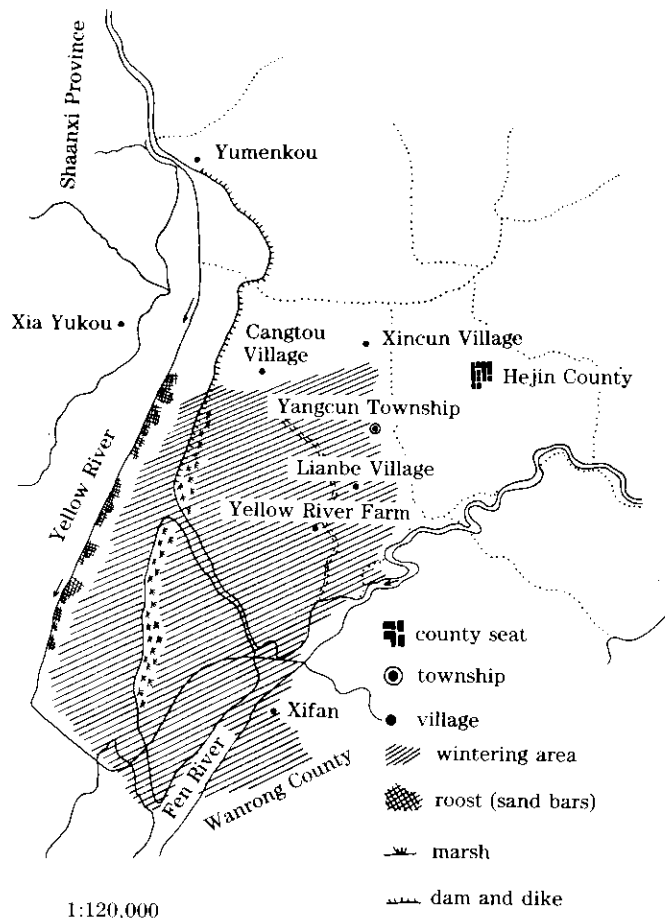


Figure 2. The wintering distribution of common cranes on the Yellow River beach of Hejin County, Shanxi.

Due to varying ecological conditions on the east side of the river, cranes still have to choose their habitat. The floodland there is large but with varied topography and low-lying uneven land that is less preferable for common cranes than open and flat ground. Although there are crops planted around Cangtuo and Lianbe Villages, common cranes rarely go there because of the dense population and frequent human disturbance. Wheat and peanut fields, far away from the residential areas, are the only places they visit. They also rarely go to floodland to the north of Cangtuo Village, where human activities are heavy and the land is narrow and gravelly. At the south end of Hejin County, where the Fen River as a boundary runs between Hejin County and Wanrong County, floodland is small in area

on the south bank. Though peanut and wheat grow there, the number of common cranes is much smaller than in Hejin because the area is close to hills and residential areas. There are protective forest belts near the dikes, and cranes never go into the forests. Sometimes large groups of common cranes come to the grassy marshland within the banks for food. Most of the time the cranes stay in large, flat peanut fields, where there is not only enough food but also less threat from enemies. Though there are wolves, people have never seen wolves posing direct danger to common cranes. It is the same case in Shandong Province (Cheng 1966).

While feeding, common cranes never mix with other birds and animals. The vegetable fields — far from residential areas and sown with carrots, beets, and sweet potatoes — are also attractive to common cranes. Common cranes like to roost on sand bars (the largest being 1-2 km long) in the Yellow River, where it is safe at night.

## DISCUSSION

The number of common cranes is obviously larger in the 1980s than in the 1960s and 1970s. This change has its historical reason. Hejin County was situated at the foot of the Luliang Mountain. Prior to the 1960s, the Yellow River changed its course several times. During flooding season, calamities often happened. The project of harnessing the Yellow River began in 1969. From then on dikes have been built. Flow of the river has become sluggish and stable. Besides, afforestation has changed the natural environment on the Yellow River beaches, making them more attractive for wintering common cranes. Moreover, since the 1980s sandy wind has become weaker, and impoverished soil has been changed into good farmland by reclamation. Floodland is of sandy loam, and has been turned into large peanut fields. After harvest, some peanuts remain in the fields, becoming the chief food resources for common cranes in winter.

Common cranes have the largest population of all crane species nowadays. In the past, they were captured and killed in large numbers. Now the government's propaganda is drawing great attention. But at the end of 1986, there were still some cases of killing common cranes during the hunting of bean geese in Shanxi. These cases should arouse the attention of the departments concerned. In order to recover and increase the number of wild common cranes, it is necessary to designate special areas for protecting these cranes in winter. I wish to make three conservation proposals.

First, we should enlarge the floodland that is fit for planting peanuts. The crop will not only bring income to the country and to the people, but also benefit the common cranes that winter there.

Second, strictly forbid hunting and killing of common cranes with locally made cannons. The departments concerned should make great effort to educate local people.

Third, while common cranes are wintering on the Yellow River beach, if there is heavy snow or deep freeze, we should take biological measures to reduce the difficulties for common cranes in looking for food.

## ACKNOWLEDGMENTS

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## OBSERVATION OF THE RED-CROWNED CRANES' WINTERING BEHAVIOR

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### ABSTRACT

From November 1986 to January 1987, we studied the wintering behavior of red-crowned cranes *Grus japonensis* at Xinyanggang in the central area of Yancheng Nature Reserve. This paper reports our observations. From 0620-0630, about 30 min after awakening, red-crowned cranes flew to their feeding place. On wet days, they would not leave until 0710. At 1700, they started flying back to their roost, a flight of 3 km. The roost was a pond covering an area of 1 km<sup>2</sup> and contained very shallow water. About 30 red-crowned cranes remained there for the night. Red-crowned cranes are social birds, but some individuals and families remained apart from the flocks. At roost, the distance between individuals of the same family was 1 to 3 m, but the distance between different families was much greater. The cranes are highly vigilant. During the day, they fly away when people come within 300 m or a Chinese water deer *Hydropotes inermes* approaches within 100 m. At night, people can approach within 50 m.

Yancheng Nature Reserve in Jiangsu Province is the largest wintering area for the red-crowned crane in the world. With the strengthening of protective and educational measures, the number of cranes has tended to increase year by year. To enhance further protection and management conditions, it is necessary to study their wintering behavior. From November 1986 to January 1987, I made a preliminary study of the red-crowned cranes' morning flight, roosting, vigilance, and calling behavior in the center of the Yancheng Nature Reserve at Xinyanggang, in Sheyang County.

### STUDY SITE

The point of observation selected was a red-crowned crane roost in the center of the nature reserve, a puddle with an area of 1 km<sup>2</sup> between observation post #1 and #5. The puddle is very small, with a water depth of 30 cm, and reeds of uneven density around it. It is an untraversed and comparatively safe region.

### MORNING FLIGHT

Day was breaking at about 0500 on a fine day in mid November. The red-crowned cranes' figures shown dimly behind the reeds, 60 m from the point of observation. All the cranes remained motionless. At 0515, one crane began to walk slowly, on guard. Soon he returned to where he started. Before long, this same crane walked in the same direction as before, and seven other cranes followed in a single file, alert and with their necks stretching forward. We observed such scenes for two days. Their activities were extremely similar throughout the observations. On 20 November at 0520, we suddenly saw three cranes flying from the southwest. Discovering that we hid among the reeds, one of the three let out a short low cry. Those on the ground quickly flew away with alarm, toward their

daytime feeding place. It was only 0540 then, and they had flown away earlier due to this disturbance. Their morning flying time from November to December was about 0620 to 0630, but they delayed the flight until 0640 or so in January. On overcast and rainy days, the flight started about half an hour later than on the fine days.

The distance between the roosting and feeding sites was so short (only 3 km) that the cranes arrived at their feeding place in no time. Most of them did not start foraging at once. They would look around. Occasionally, two or three of them would briefly spread their wings, dancing. They would begin to feed 15 min after they reached the site. Cranes in a family would take turns looking up and around with vigilance.

### ROOSTING BEHAVIOR

The cranes returned to their roosts at about 1700. This time would be moved up, however, by 15-30 min on rainy and overcast days. At the roost, the cranes didn't stop moving about immediately, particularly on fine days. For example, at 1700 on 20 November, they could be seen walking slowly or pecking at food in water, or looking up, but all within a very small range. After 1800, the cranes began to get behind the reeds nearby. Even at dusk, a few of them were still moving about. Between the time of cranes' arriving at the roost and falling asleep, loud calls could often be heard. At about 2100, they became quiet, except for a group of 15 cranes that stood scattered in an area of 100 m<sup>2</sup>.

The distance between the individuals of the same family was 1-3 m. The distance between different families was much greater. At night, the crane parents would let out a low cry, "Du du du du," if their young were a little too far from them. At the sound, the chicks would quickly return to their parents' side. At night, the crane flocks were very quiet with just a few low sounds. During their sleep, the cranes thrust their beaks under their wings, with one

foot standing. At about 0500, at dawn, they would draw back their necks while standing, a different pose than at night.

#### VIGILANCE

The cranes are social birds that live in family units. Owing to the strict protective measures and people's care for the cranes, there are no wild beasts that will harm cranes in the reserve area. The cranes, however, still maintain sharp vigilance. They would fly away when people were at a distance of 300 m from them, but would not be disturbed when we were 500 m away. At 1320 on 20 November, a family of three cranes were foraging in the reeds when they suddenly flew away with alarm. They flew about 3,000 m. They had seen a Chinese water deer 100 m away from their feeding place, hidden among high reeds — the cranes have extremely sharp eyesight and hearing.

It is easier to get close to the cranes at night, since their eyesight in dim light falls far short. Behind reeds, we could get as close as 50 m away. Under a full moon, however, it was not easy to approach any closer than 100 m. On 18 November, a flock of roosting cranes was disturbed and flew away because of the sound of our feet on the reeds. We were only 30 m away. We estimate that they flew 4,000 m away according to their fading cries. In dark nights, we could get 20 m away from them without being discovered. Sometimes, cranes would approach as close as 5 m from us.

#### CALLING

The crane calls were mainly heard during morning flight

and at the roosts, especially at evening. On 17 November from 1720-1726, we counted 81 calls. Of the 81 calls, half were made in series one after another.

When night fell, the cranes would become vigilant as soon as they discovered anything unusual. The whole process of discovering disturbance, giving alarm signals and flying away took very little time.

On 18 November at 2000, the cranes let out calls like, "Ge ge ge ge," when we approached a flock. A few seconds later, as they realized that danger was closing in, they gave very low warning calls a little like a swift retroflex of humans—"Tre re re"—. The warning calls were repeated 4-5 times, then quiet a few seconds until at last they let out a long, "Trererererere." As soon as the last call stopped, birds flapped wings and flew away, letting out several loud calls like "Gea gea gea gea." When they flew farther away, the calls became "Gao gao," for more than 30 times.

The cranes' calls could also be heard deep in the night. We recorded the crane calls on the night of 20 November. They were at 2315, 4 calls; 0150, 4 calls; 0300, 7 calls; and 0340, 14 calls.

#### SOLITARY CRANES

We found one solitary crane at the center of the reserve. It often moved and fed alone, and was often the last to come back to the roost in the evening.

When it met a crane family, it always tried to avoid them. During a 30-min observation from 0930 to 1000 on 19 November, a family of three cranes approached three times. Each time, the lone bird immediately withdrew by walking around the group, and stopped only 10 m away.

#### ACKNOWLEDGMENTS

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## THE CONSERVATION AND MANAGEMENT OF CRANES AT SHENGJIN LAKE IN ANHUI PROVINCE

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### ABSTRACT

Shengjin Lake is south of the Yangtze River in western Anhui Province, with an area of 133 km<sup>2</sup>. It is rich in aquatic resources and has 50 species of water birds. The hooded cranes *Grus monacha* wintering there are the largest population of the species in China. Other large water birds are: white-naped crane *G. vipio*, Siberian crane *G. leucogeranus*, common crane *G. grus*, white stork *Ciconia boyciana*, black stork *C. nigra*, white spoonbill *Platalea leucorodia*, tundra swan *Cygnus columbianus*, and great bustard *Otis tarda*. The ecosystem of Shengjin Lake is being degraded by reclamation of the lake for farmland, overfishing, the use of pesticides to kill snails, and overhunting. A nature reserve is now set up to strengthen conservation and management, and measures have been taken to protect the environment and resources of Shengjin Lake.

### NATURAL CONDITIONS

Shengjin Lake is located in the lower reaches of the Yangtze River in China, on the south bank of western Anhui Province, facing the City of Anqing across the river (15 km between Anqing and Shengjin). It is located at 30° 16' 26" N and 116° 58' 11" E. The southern part of the Dabie Mountains are northwest of Shengjin Lake, and run from north to south; the highest point, Mt. Tianzhu (1,485 m in altitude), is 70 km from the lake.

Shengjin Lake has an area of 133 km<sup>2</sup> and a perimeter of 165 km, and an average width of 7.5 km. The bottom of the lake is flat with 80% silt. The depth of the water is about 0.8 m in winter and less than 3 m in summer. There are 13 towns and 46 villages with a total population of 80,000. Most of the people living here grow cotton and rice. People in one of the villages live on fishing and on hunting wild ducks. Shengjin Lake runs northwest into the Yangtze River; at the entry to the river, the Huangpeng Gate controls the water level. The seasonal fluctuation of its water level follows the same pattern as the Yangtze. Every autumn and winter when the water retreats, mudflats and wetlands appear at the upper reaches of the lake, attracting many large southbound water birds to stop or winter here.

Shengjin Lake is rich in aquatic resources. It contains 61 species of fish, including *Cyprinus carpio*, *Carassius auratus*, *Siniperca chuatsi*, *Culter erythropterus*, *Elopichtys bambusa*, *Ophiocephalus argus*, *Parasilurus asotus*, *Acanthorhodeus taenianalis*, and *Pseudobagrus fulvidraco*. The Huangpeng Gate, however, now prevents young fish from entering the lake. There are 18 species of mollusks, including *Cipangopaludina chinensis*, *Bellamya quadrata*, *Radix auricularia*, *Limnoperna lacustris*, *Hyriopsis cumingii*, *Anodonta woodiana*, *Cristaria plicata* and *Corbicula fluminea*. There are 55 species of

aquatic and partially aquatic vascular plants. The main species are *Euryale ferox*, *Ceratophyllum demersum*, *Trapa maximowizii*, *Nymphoides peltatum*, *Potamogeton malainus*, *Vallisneria spiralis*, *Phalaris arundinacea* and *Carex unisexualis*.

### CRANES AND OTHER WATER BIRDS WINTERING AT THE LAKE

According to the author's survey, there are 50 species of water birds in Shengjin Lake (see Appendix 1). Among them are four species of cranes: hooded, white-naped, Siberian, and common cranes.

#### Hooded Crane

The main habitats of hooded cranes at Shengjin Lake are the mudflats of its upper reaches (see Figure 1). Hooded cranes arrive in early November and leave in late March of the following year, wintering here about 145-150 days. Sometimes the cranes leave in early April. For example, they were last seen on 15 April 1984 and 8 April 1985. A continuous survey from 1980-1986 shows that hooded cranes feed and live here all winter. From 1980-86, the population has averaged about 200 individuals (there were 280 on 16 March 1983, and 360 on 3 January 1987). Hooded cranes congregate in large groups to roost. During the day, however, they split into small family groups to feed. Most of the crane families consist of one adult pair with one young, or occasionally one adult pair with two young. Although hooded cranes are also found at Poyang Lake in Jiangxi Province and Junshan Reserve in Hunan Province, the numbers are fewer than those at Shengjin Lake. The total number of hooded cranes wintering in the lower reaches of the Yangtze River includes over 500 individuals (Ding and Zhou 1982; Ding 1985; Zhou this proceedings).

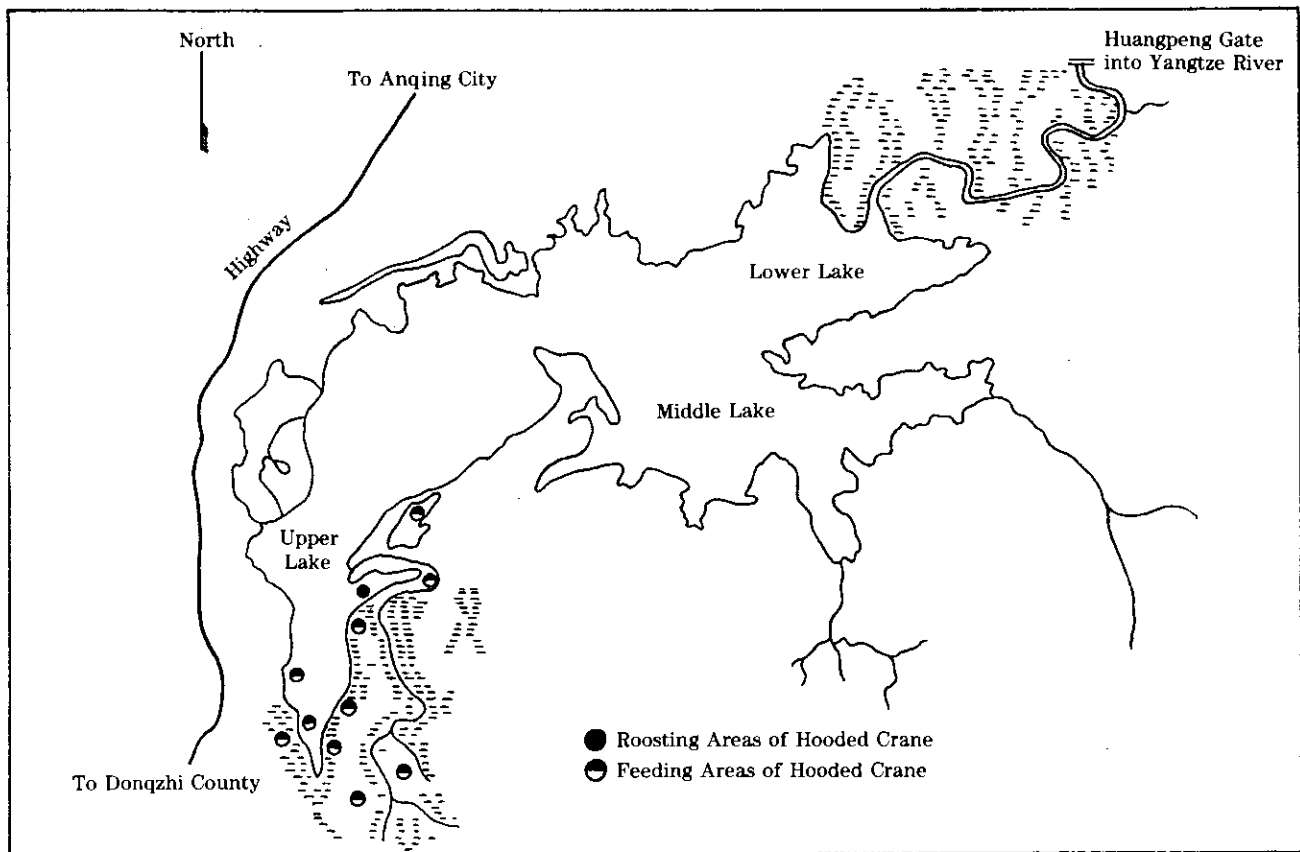


Figure 1. Feeding and roosting areas of hooded cranes at Shengjin Lake, Anhui.

#### White-naped Crane

White-naped cranes winter on beaches of the upper reaches of Shengjin Lake. The population is small; there were 19 individuals on 25 December 1981, and 34 on 16 December 1982. The number increases, however, during migratory seasons; there were 100 individuals in March 1981, and more than 500 on 16 March 1983. White-naped cranes usually wander on slightly dried beaches and do not socialize with hooded cranes.

#### Siberian Crane

Only a few Siberian Cranes are found in Shengjin Lake (there were 15 individuals on 10 December 1986). This number increases during migrating seasons. Forty individuals were seen (including 6 young) mixed with more than 500 white-naped cranes on 16 March 1983. An earlier record for the Siberian crane in Anhui came from Anqing City, where one adult male and one young female were captured in December 1953. The specimens are now in Shanghai Nature Museum. From 1982 to 1986 in early November and mid March, Siberian cranes were captured in Luan, Huoqiu, Huoshan, Yuexi, Lujiang and Feixi Counties in Anhui Province. These records indicate that Siberian

cranes pass through the east side of the Dabie Mountains during migration.

#### Common Crane

The number of common cranes at Shengjin Lake is very small. Only one was found on 23 December 1979 and six on 25 October 1982.

#### Other Water Birds

Among other water birds, coot *Fulica atra* and pintail *Anas acuta* are the dominant species. There are also many white storks, white spoonbills and great bustards, and a few tundra swans and black storks at Shengjin Lake. Each year, there are about 100 white storks (118 in 1981, and 125 in 1985), about 200 white spoonbills (300 on 25 January 1986), and about 100 great bustards (84 on 16 March 1983, and 200 on 14 February 1986). From a taxonomic point of view, the main water birds in Shengjin Lake belong to Ciconiiformes, Anseriformes, Gruiformes, Charadriiformes and Lariformes. The water bird fauna at lakes along the lower reaches of the Yangtze River is about the same as that at Shengjin Lake. There are some differences in species and numbers between places, depending on the sizes of the lakes and the degree of human disturbance.

## CHANGES OF THE ECOSYSTEMS

Shengjin Lake is rich in aquatic resources. The annual output of fresh fish in 1954 was 3,000 tons. The water is shallow and the beaches are wide. But in recent decades, the ecosystems of Shengjin Lake have worsened, with effects on all aquatic resources. The output of fish, for example, has decreased since 1965 after the building of sluice gates: 1,175 tons in 1974, 54 tons in 1978, and 40 tons in 1982. The main factors at Shengjin Lake are as follows.

1. The reclamation of the lake for farmland has resulted in a decrease in water bird habitats. Beginning in 1958, there has been large scale reclamation at the lake, covering an area of 66 km<sup>2</sup>.

2. Overfishing has led to a decrease in fish output. The isolation of lakes from the Yangtze River due to the building of sluice gates prevents fish from migrating and spawning. Destructive fishing by using illegal fishing tools results in the decrease of aquatic resources. The water birds wintering here not only lack food, but also find it hard to live in shallow water areas full of fish nets.

3. The usage of sodium pentachlorophenol to kill snails *Oncomelania hupensis* has resulted in water pollution, killing many aquatic organisms and destroying the ecological balance. Shengjin Lake is an epidemic region for blood fluke *Schistosoma japonicum*. In the past, sodium pentachlorophenol was used to kill *Oncomelania* each spring and autumn. The situation is improving in recent years since use of this chemical ended.

4. Disturbances from human activities and overhunting. Grazing and catching fish and shrimp, as well as farming on beaches, seriously affect the habitats of water birds. A fishing and hunting team of 245 persons at the Shengjin Lake area killed 128,912 water birds from 1976 to 1982, including 100,277 wild ducks, 1,491 wild geese, 27,073 coots, and 71 cranes. Another team killed 1,500 wild ducks on

24 December 1979, including 21 mallards *Anas platyrhynchos*, 18 Baikal teals *A. formosa*, 30 common teals *A. crecca*, 8 wigeons *A. penelope* and 1 shoveller *A. clypeata*. The remainder were all pintails.

## PROTECTION AND MANAGEMENT MEASURES

Shengjin Lake supports the largest known wintering flock of hooded cranes in China. It is also a wintering area for white storks, white spoonbills and great bustards, as well as a major stopover for migrating Siberian and white-naped cranes. To strengthen protection, the following measures are important.

1. Establishing the Shengjin Lake Water Bird Nature Reserve on the basis of a survey from 1983 to 1985. In 1986, the government of Anhui Province approved the organization of a Management Station at Shengjin Lake Nature Reserve, with an area of 330 km<sup>2</sup>. Basic construction of the reserve is underway, and protection measures are being conducted.

2. Taking effective measures to protect aquatic ecosystems. Grazing and cutting grasses on beaches should be restricted, as should release of industrial sewage in the lake. Hunting of water birds should be forbidden, and illegal fishing tools banned.

3. Emphasizing publicity and education, and strengthening the legal system. Farmers living in the lake area should be taught the importance of water bird protection, and we should help them find appropriate substitute sources of income. Public security organizations should be set up to enforce the law, and to penalize those who break it.

4. Conducting systematic and detailed scientific research to provide a scientific basis for water bird conservation. We should cooperate with institutions of higher learning to conduct research on aquatic ecosystems in terms of the lake area environment, water bird ecology, and aquatic resources.

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## APPENDIX 1

## List of water birds at Shengjin Lake

## PODICIPEDIFORMES

## Podicipedidae

1. *Podiceps ruficollis poggei* little grebe

## CICONIIFORMES

## Ardeidae

2. *Ardea cineracea rectirostris* gray heron
3. *Egretta alba modesta* great egret
4. *Egretta garzetta garzetta* little egret
5. *Egretta intermedia intermedia* intermediate egret

## Ciconiidae

6. *Ciconia boyciana* white stork
7. *Ciconia nigra* black stork

## Threskiornithidae

8. *Platalea leucorodia leucorodia* white spoonbill

## ANSERIFORMES

## Anatidae

9. *Anser cygnoides* swan goose
10. *Anser fabalis serrirostris* bean goose
11. *Anser albifrons albifrons* white-fronted goose
12. *Cygnus columbianus jankowskii* tundra swan
13. *Tadorna ferruginea* ruddy shelduck
14. *Tadorna tadorna* common shelduck
15. *Anas acuta acuta* pintail
16. *Anas crecca crecca* common teal
17. *Anas formosa* Baikal teal
18. *Anas falcata* falcated teal
19. *Anas platyrhynchos platyrhynchos* mallard
20. *Anas poecilorhyncha zonorhyncha* spotbill duck
21. *Anas strepera strepera* gadwall
22. *Anas penelope* Eurasian wigeon
23. *Anas querquedula garganey*
24. *Anas clypeata* northern shoveler
25. *Nettion coromandelianus coromandelianus* cotton pygmy goose

## GRUIFORMES

## Gruidae

26. *Grus grus lilfordi* common crane
27. *Grus monacha* hooded crane
28. *Grus vipio* white-naped crane
29. *Grus leucogeranus* Siberian crane

## Rallidae

30. *Amaurorinis phoenicurus* white-breasted waterhen
31. *Fulica atra* coot

## Otidae

32. *Otis tarda dybowskii* great bustard

## CHARADRIIFORMES

## Charadriidae

33. *Vanellus vanellus* northern lapwing
34. *Vanellus cinereus* gray-headed lapwing
35. *Pluvialis dominica fulva* eastern golden plover
36. *Charadrius hiaticula* ringed plover
37. *Charadrius dubius curonicus* little ringed plover
38. *Numenius arquata orientalis* Eurasian curlew
39. *Tringa erythropus* spotted redshank
40. *Tringa nebularia* greenshank
41. *Tringa ochropus* green sandpiper
42. *Gallinago gallinago* common snipe
43. *Scolopax rusticola rusticola* Eurasian woodcock
44. *Calidris alpina sakhalina* dunlin
45. *Calidris ferruginea* curlew sandpiper

## Recurvirostridae

46. *Recurvirostra avosetta* avocet

## LARIFORMES

## Laridae

47. *Larus argentatus regae* herring gull
48. *Larus ridibundus* black-headed gull

## CORACIIFORMES

## Alcedinidae

49. *Ceryle rudis insignis* lesser pied kingfisher
50. *Alcedo atthis bengalensis* common kingfisher

## WINTER ECOLOGY OF HOODED CRANES

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## ABSTRACT

Observations were made on the winter ecology of hooded cranes *Grus monacha* from December 1983 to January 1984 at Wucheng at Poyang Lake in Jiangxi Province, from December 1985 to January 1986 at Jianxin farm near Dongting Lake in Hunan Province, and in November 1986 at Chongming Island, Shanghai. During the last ten days of November, flocks of hooded cranes arrived at their winter areas; in the middle of March, hooded cranes began to leave. The hooded crane stays in the wintering area for nearly 130 days. The cranes are gregarious in three types of flocks: family groups, conspecific groups, and mixed species groups. Hooded cranes predominantly eat herbivorous foods, particularly grains, as well as a very small quantity of shellfish. There is no difference in food preference between adults and young.

The hooded crane is ranked in China as a first class protected animal. Its major breeding region is in Siberia, U.S.S.R. There is a record of its breeding in Heilongjiang Province, China (Chen 1987), but its exact breeding region has not been found in recent years. A large number of hooded cranes winter in Japan, and only small numbers winter in the areas along the middle and lower reaches of the Yangtze River of China. I studied their winter ecology at Wucheng, on the shore of Poyang Lake in Jiangxi Province during the period between winter 1983 and spring 1984, at Jianxin Farm on the shore of Dongting Lake, Yueyang City, Hunan Province from December 1985 to January 1986, and on Chongming Island, Shanghai in November 1986.

## WINTER DISTRIBUTION AND NUMBER

Relevant observations and reports in China indicate that hooded cranes winter mainly in the south of our country. There is evidence of their distribution in the provinces of Jiangsu, Anhui, Jiangxi, Hunan, Hubei, Guizhou and Shanghai. Their major wintering region, however, is in the area along the middle and lower reaches of the Yangtze River, especially at Shengjin Lake in Anhui Province, at Poyang Lake in Jiangxi Province, at Dongting Lake in Hubei and Hunan Provinces, and on both banks of the Yangtze River. The group wintering at Poyang Lake consists of about 160 birds, formerly considered the largest group wintering in China. The flock at Shengjin Lake in Anhui Province numbered about 140 but now there are about 300. In Hunan and Hubei Provinces, there are about 60; the groups wintering in other places total about 20 birds. According to these statistics, the total number of hooded cranes wintering in China is less than 500.

[Table 1 summarizes counts of hooded cranes from 1985-90. The recently discovered wintering site at Longgan Lake in Hubei was not included in the estimate of 500 hooded cranes in China.]

Location	Date	Number	Observer
Junshan Nature Reserve Jianxin Farm Yueyang, Hunan	Dec. 23, 1985	55-60	Jianxin Farm
Poyang Lake Jiangxi	Dec. 9, 1986	165	reported in <i>Jiangxi Daily</i>
East Chongming Island Shanghai	Nov. 3, 1987	21	author
East Chongming Island Shanghai	Dec. 1989	about 100	Chongming Bird Protection Station
Shengjin Lake Anhui	Jan. 3, 1987	360	Shengjin Nature Reserve
Shengjin Lake Anhui	Dec. 1988	250	Shengjin Nature Reserve
Xinglongsha Qidong, Jiangsu	Jan. 24, 1989	38	author
Longgan Lake Huangmei, Hubei	Feb. 19, 1990	280-300*	author

Table 1. Numbers of wintering hooded cranes in China<sup>a</sup>.

<sup>a</sup>Editor's note: this table includes records after 1987; the major wintering area at Longgan Lake in eastern Hubei was not known in 1987, and thus the cranes there were not included in the author's estimate of less than 500 hooded cranes wintering in China.

## HABITAT

The habitat for wintering hooded cranes in China is different from that of the Siberian crane *G. leucogeranus* and the white-naped crane *G. vipio*, but similar to that of the common crane *G. grus*. Hooded cranes are seldom seen

wading in shallow water of rivers and lakes. They stay on wet mudflats or grass marshes by the rivers and lakes where the water level has dropped (e. g., Poyang Lake). They also stay in fallow fields on the shore of rivers and lakes (Dongting Lake, Yueyang City). Sometimes they can be seen in low reeds by the river sides (Chongming Island, Shanghai).

#### OBSERVATIONS OF BEHAVIOR AND ECOLOGY

In the last 10 days of November each year, the hooded cranes move in succession to their winter region. They have the habit of moving about in family groups. A family usually consists of two adults and a young hatched that year. There are a small number of families consisting of two adults and two young birds. I once found on Chongming Island a solitary crane that was looking for food on the grass marsh about 100 m away from other families. Families, usually two or three, stay loosely together while looking for food; but lone family units can also be found.

The hooded cranes staying on the shore of Dahuchi, south of Wucheng in Jiangxi Province, are not timid — they have familiarized themselves with human activities so that they stay close to roads where people and domestic animals come and go. Hooded cranes move about freely in files over the wet mud around the lake. They dig with their beaks while walking along slowly. Sometimes the mud accumulates on their toes; they shake their toes one by one to get rid of the mud. When they are observed from 200 m away, hooded cranes show no fear, except that they sometimes look up from their feeding. If you go near them, in most cases, they do not fly very far but land on the wet mud and continue looking for food. If you go much nearer, they leave the ground wheeling in the air and crying. When they know there is no hope of your leaving, they flap their wings flying to other lake districts. If there is no disturbance, however, they stay at one place day and night and seldom move to other places.

At Dongting Lake, there were two flocks, one consisting of 18 birds, the other of 40. Sometimes, the two groups stayed together, but in most cases, they moved about separately, frequenting fallow rice fields near the dam. Many alfalfa seeds were spread in the harvested rice fields, and rice remained after the harvest. Crows *Corvus* spp., ruddy shelducks *Tadorna ferruginea*, and spotted doves *Streptopelia chinensis* fed on rice in the fields. Hooded and common cranes often mixed with these birds without conflict. Hooded cranes slowly move around in family groups looking for food, but were often disturbed by people and dogs. Cranes here are very timid and look about vigilantly while eating. When you approach to a distance of 200 m, first some families fly, then the others follow in succession. Often two or three families do not leave with the rest of the flock. They remain on the ground until you get very close. When danger passes, hooded crane return to the rice fields after wheeling in the air for some time. If you do not leave, they wheel higher and higher in the air and arrange themselves in a file or in "V" shape and then fly to the grass marsh outside the dam or to nearby fields. In most cases,

they return to the rice fields at dusk to spend the night. Rarely do they change their night habitat. At night when they stay together with ruddy shelducks and crows, the ducks and crows will be disturbed and fly up first when people approach. In the fields where cranes roost, their droppings can be found. These droppings are long and narrow like feces of geese, sometimes stained with white spots. The droppings contain mostly small bits of rice shells. Hooded cranes are also found digging and eating the sedge roots in the sedge marsh outside the dam.

At the beginning of March, weather turns warm gradually. The alfalfa seeds planted in the rice fields begin to germinate so that they cover the rice left in the fields. During this period, at dawn (about 0600) when the sun has not risen yet, hooded cranes leave the rice fields where they have spent the night and look for food on the muddy edges of lakes, near the Yangtze River or in Hubei Province. At about dusk, they return to their original roosting ground. Sometimes, if it is cloudy or raining, they'll return at 1400 or 1500. During the second 10 days of March, the number of hooded cranes wintering in the south is decreasing little by little. By the last 10 days of March, all will have left their wintering region.

#### MEASUREMENTS AND FOOD

On 21 February 1986, in the rice field of Jianxin Farm, at Junshan Nature Reserve (Dongting Lake) in Hunan Province, we found three hooded cranes that had been poisoned: one adult female, and two young males with yellow-brown feathers on their heads and necks (poisons are used commonly in the Yangtze River valley to capture birds).

The measurements of the three birds appear in Table 2. Results of the analysis of food found in their stomachs appear in Table 3. Their major food was rice, with small amounts of clams and snails.

No.	Sex	Weight (g)	Body mm	Wing mm	Tail mm	Culmen mm	Tarsus mm
1	♂	3450	970	473	171	100	210
2	♀	3350	940	464	179	93	207
3	♂	3500	952	468	169	93	208

Table 2. Measurements of three hooded cranes at Dongting Lake, Hunan.

No.	Contents of Stomach		Food Type and Amount (g)			
	Wet Weight (g)	Capacity of stomach (cc)	Sand	Rice	Clam Shell	Snails
1 (♂)	61	40	13	23	2.2	1
2 (♀)	62.5	37	12.5	16.5	0.25	0.25
3 (♂)	50.7	32.5	7.5	18	0.45	0.45

Table 3. Analysis of stomach contents for three hooded cranes.



#### ACKNOWLEDGMENTS

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# OBSERVATIONS ON WINTERING ECOLOGY OF CRANES AT POYANG LAKE

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## ABSTRACT

Cranes are the most precious of birds at Poyang Lake, especially among the wintering birds. We investigated cranes and other rare birds at Poyang Lake during winter and spring every year from December 1983 to December 1986, six months in all during three years. In this paper, we report our observations of Siberian cranes *Grus leucogeranus*, white-naped cranes *G. vipio*, hooded cranes *G. monacha*, and common cranes *G. grus*.

## NATURAL ENVIRONMENT

Poyang Lake is on the north verge of the mid-subtropical zone, at the mid and lower reaches of the Yangtze River and the northern part of Jiangxi Province. It is located at 28°20' to 29°50' N and 115°50' to 116°45' E. It is the biggest freshwater lake in China. It covers an area of about 4,646 km<sup>2</sup> during flood season but only 500 km<sup>2</sup> in the dry season. The flood season is between April and September, the dry season between October and March.

The water of Poyang Lake comes from five big rivers — Gan, Fu, Xiu, Rao, Xing — and two smaller rivers. In total, these rivers have an average annual flow of 145.7 billion cubic meters carrying 21.04 million tons of silt (Poyang Lake Study Editorial Committee 1988). Day after day, year after year, the sediment area becomes bigger and higher with more and more silt deposited. During the dry season marshland and countless small lakes form (about 30-80 cm deep).

Poyang Lake Nature Reserve for the migratory birds is located on the west bank of Poyang Lake. There are nine small lakes in the reserve (including Dahuchi, Banghu, Dachahu, Zhonghuchi) formed on the flood plain in the dry season by natural sand dikes. The Poyang Lake area has a subtropical wet monsoon climate; the average yearly temperature is about 17°C and the average temperature in winter is about 5°C. The average water temperature is about 6.2°C. Due to the open marshes and shallow lakes, water plants and water animals are abundant; plankton counts totaled 449,300 water plants per liter and 6,996 water animals per liter (Wang et al. 1987). With little human disturbance, the area provides the cranes with an excellent wintering ground.

## SPECIES AND NUMBERS OF CRANES

There are four species of cranes wintering at Poyang Lake: Siberian, white-naped, hooded, and common cranes.

According to historical records, there were red-crowned cranes *Grus japonensis* at Poyang Lake but we have not found any in recent years. White-naped cranes have the largest number (about 2,200 on 5 January 1986 at Dahuchi). There were 1,609 Siberian cranes in January 1987 at Dahuchi, 178 hooded cranes on 30 December 1985 at Dahuchi, and 109 common cranes on 1 January 1986 at Dahuchi.

Cranes at Poyang Lake are distributed mostly in the west part of the reserve. They also feed in the south part of the reserve for short periods. According to our observations, the number of cranes has been increasing quickly in recent years. We think the reason is that the living and feeding conditions here are better than at other places in the region. We pay more attention to protecting cranes here and keep a safe environment for them, so that cranes from areas that suffer from environmental damages and human disturbance are drawn to the reserve. Table 1 illustrates this.

During our survey, we observed the proportions of young birds in the crane populations.

Species	Year					
	1981 <sup>a</sup>	1982 <sup>a</sup>	1983	1984	1985	1986
Siberian crane	148	189	450	840	1483	1510
White-naped crane	26		700	1162	1900	2200
Hooded crane			73	115	178	210
Common crane				20	109	95

<sup>a</sup> 1981 and 1982 data from Wang et al. (1987).

**Table 1.** Numbers of cranes at Poyang Lake.

## Siberian Cranes

Siberian crane families at Poyang Lake usually have three birds: two parents and one chick. Sometimes there are two birds: one parent with one chick. The numbers of young Siberian cranes according to our observations are: December 1981, 10 chicks in 91 birds, about 10.9%; 31 December 1983, 81 chicks in 611 birds, about 13.3%; 8 January 1984, 15 chicks in 154 birds, about 10.0%; 30 December 1985, 205 chicks in 1,378 birds, about 14.8%; 20 December 1986, 156 chicks in 1,285 birds, about 12.2%.

## White-naped Cranes

Most white-naped crane families are parents with two chicks: 11 December 1985, 95 chicks in 417 birds, about 22.8%; 30 December 1985, 211 chicks in 824 birds, about 25.6%.

## Percentages of Chicks

From the above data, we can see that chicks comprise 12.3% of the Siberian crane population on average; the percentage of white-naped crane chicks is higher.

We are not sure about the percentage of chicks for hooded and common cranes. These two species are of darker color. Our equipment is not good enough to see them clearly from far away. We used telescopes to observe small flocks from a short distance. We think that the average percentage for both species is about 20-29% per year.

## MIGRATION

It is already very cold at the breeding area in October, but it is still warm in Poyang Lake. The lowest temperature there is about 11° C. Each year during this time, cranes are migrating from north to south to spend their winter in Poyang Lake.

## Arrival and Departure Dates

Arrival and departure dates for each crane species can be seen in Table 2. Siberian and white-naped cranes arrive earlier than hooded cranes, and they all spend about 4-5 months in winter at Poyang Lake. The time of migration depends on the temperature of the year. The cranes fly south earlier if it is cold earlier in the north. Departure for the north depends on the local temperature, sunlight, and water level of the lakes. At the end of March, it begins to rain continuously, and the water level rises in Poyang Lake. Feeding places of Siberian and white-naped cranes are flooded, so the cranes begin to fly north. Hooded cranes usually feed in water about 5-20 cm deep. They don't start flying north until the beginning of April.

Siberian cranes depart at noon, especially on warm and clear days. On 19 March 1986, for example, it was mild and sunny. From 1100 to 1140, three groups containing 50, 32, and 48 Siberian cranes called and took off from Dahuchi, flying up about 500 m in the air. Then they were circling and flying up to more than 1,000 m. They then flew west

until we could not see them with a 60X telescope. White-naped cranes fly to the north in good weather, too. Time of departure is earlier, however, at about 0930. There are usually 50-100 cranes in a group, circling, calling, and then flying to the north. Their flying altitude is lower than for Siberian cranes. The hooded cranes arrive and depart rather late in the season.

Species	Winter 1983-84	Winter 1984-85	Winter 1985-86
<b>Siberian Crane</b>			
Arrival date	Dec. 13	Nov. 6	Oct. 31
Number of cranes	50	7	207
Departure date	April 6	April 3	May 29
Number of cranes	3	2	22
Length of stay	144	147	149
<b>White-naped Crane</b>			
Arrival date	Nov. 18	Nov. 12	Nov. 9
Number of cranes	10	4	6
Departure date	April 1	April 6	March 22
Number of cranes	2	46	21
Length of stay	132	144	132
<b>Hooded Crane</b>			
Arrival date	Dec. 9	Nov. 6	
Number of cranes	13	3	
Departure date	April 9	April 9	
Number of cranes	10	9	
Length of stay	116	151	

Table 2. Arrival and departure of cranes at Poyang Lake.

## ECOLOGY OF CRANES

### Different Ecological Niches

Siberian cranes find their food in water 10-20 cm deep. They eat *Vallisneria spiralis*, *Potamogeton malainus*, *Carex* spp., *Eleocharis valliculosa*, etc., which contain considerable protein, carbohydrate, fat, and vitamin. *Potamogeton malainus*, for example, is 5.94% protein, 0.60% coarse fat, 22.06% coarse fibers, 0.026% phosphorus, 4.31% calcium, and 4.42% iron. They also eat small quantities of clams and snails in winter. They mostly stay in family groups; subadults are in groups of 10-50. You can find white-naped cranes among them sometimes. Siberian cranes like to feed and roost in the same lake area. Most of them will fly to a bigger and quieter lake if they are disturbed. In the past few years, we observed that they look for their food from one lake to another. First, they were in Xianghu; half a month later, all flew to Changhuchi. In the spring of 1984, they were in Dahuchi and Banghu; but in 1985-1986, all of them were in Dahuchi. At the end of 1986, they were in Zhonghuchi, Dahuchi, and Banghu. We think the changes are because of disturbance and levels of water.

White-naped cranes look for their food in water 5-20 cm deep in the marsh areas. After rain, or before migrating north, they find things to eat on grassland. They have the same ecological niche as swan geese *Anser cygnoides*. We think that there is feeding competition among swan geese, Siberian cranes, and white-naped cranes.

Compared with the other cranes, hooded cranes are few in number. Their foraging area is drier than other cranes — mudflat. They often feed with pigs on the banks of lakes. They look for food in the holes that pigs dig. They eat roots of *Cyperus* spp., corn *Zea Mays*, and wheat *Triticum aestivum*. Accordingly, they are likely to be poisoned to death. Hooded cranes feed at one lake and roost at another. They begin to look for food at 0730-0800. We found three families each of three hooded cranes at Changhuchi all the years of our study. The speed of feeding for hooded cranes is very fast, probing about 70 times in 1 min. They eat less, however, when it is snowing.

#### Difference in Habits

Siberian cranes are very alert. One cannot get closer to them than 200 m before they will fly away. Siberian cranes are more territorial than other cranes. Siberian cranes always chase white-naped cranes that are feeding nearby. Siberian cranes sometimes chase each other, too. Chicks follow their parents and are fed by parents once every 4 min.

White-naped cranes are timid, especially the males. They will stop eating at danger signals. They will fly away when you are still 300 m away. They are very active, calling, dancing, and playing, especially after it has rained. There are often two chicks in one white-naped crane family.

Hooded cranes are bolder and quieter. One can get as close as 80 m from them before they fly. They call less and do so when they fly and rest.

#### PROTECTION MEASURES

At Poyang Lake, there are over 4,000 cranes and a large number of wintering swan geese, great bustards *Otis tarda*, white and black storks *Ciconia boyciana* and *C. nigra* and many other birds. Accordingly, it is very important to protect the environment of these areas. We propose the following actions.

Certain water levels should be maintained. In order to manage the fish and provide enough food for wintering birds, the depth of the water in the lakes must remain no more than 50 cm. We should completely change the wrong practice of letting all the water out in order to capture fish in the marshes.

Hunting and poisoning should be strictly forbidden. If it is necessary to catch birds for scientific research and education, permission should be obtained.

Extra food should be supplied artificially for the birds, in order to keep enough food for the wintering birds and let birds become accustomed to humans. We should set out corn and wheat within the reserve and bird watching spots.

In order to avoid competition between cranes and swan geese for food, and also dangers of disease transmission, we suggest that the protection area be enlarged at Poyang Lake Nature Reserve around Nanhu to the west, Xiaochahu to the east, and Chandouhu to the south. The birds would then be able to disperse more widely.

Research efforts should be enhanced as a basis for protecting the balance of ecology and the welfare of people. We should do more work on diseases of cranes.

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# THE WINTERING ECOLOGY OF THE SIBERIAN CRANE

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## ABSTRACT

During the winters of 1984-85 and 1985-86, we observed wintering Siberian cranes *Grus leucogeranus* at the Lakes Dahuchi and Banghu that belong to Poyang Lake Migratory Bird Reserve, a reserve that covers 224 km<sup>2</sup>. The largest number of wintering Siberian cranes was 1428 in February 1985 and 1784 ( $\pm 40$ ) in January 1986. Siberian cranes took nine hours to look for food every day, their staple foods being buried tubers and roots of bambooleaf pondweed *Potamogeton malainus* and other hydrophytes. Young Siberian cranes did not dig for food before February. They were fed by their parents one to seven times every 5 min., on average 5.3 times. Thirty days before migrating north, the young cranes began to increase the time they spent digging food. At night, Siberian cranes roosted in shallows at the center of the lake, standing close together and facing the wind. The number of birds and the direction they faced was related to temperature and wind direction. From mid to late March, Siberian cranes departed north on migration from 1100 to 1200. Usually each family had but a single chick.

## GEOGRAPHIC LOCATION AND HABITAT

Poyang Lake Migratory Bird Reserve, in northern Jiangxi Province on the west side of Poyang Lake, covers 224 km<sup>2</sup>. It is located at 115° 55'-116° 03' E and 29° 05'-29° 15' N. It can be described as a floodplain in spring and summer and a string of gradually drying lakes in autumn and winter. It has a subtropical warm and wet climate with sufficient sunshine, ample precipitation and a long frost-free period. The average annual rainfall is 1,300-1,800 mm. There are four seasons in this region where aquatic plants and animals are abundant. Here environmental pollution is very light. All of these factors favor cranes and other migratory birds.

## PHYSICAL MEASUREMENTS OF THE SIBERIAN CRANE

The Siberian crane is also called Asian white crane or black-wing crane. On 2 January 1987, we found a subadult crane with a body weight of 6,500 g, body length of 1,200 mm, bill length of 179 mm, wing length of 528 mm, tarsi length of 243 mm, and tail length of 207 mm.

## OBSERVATION METHODS

We used a 30-60X telescope for our observations. From 1 November 1984 to 25 March 1985 and from 25 October 1985 to 31 March 1986, we spent 4-5 hours each day on observation at Dahuchi, Banghu, Zhonghuchi, and Xianghu; we made observations for whole days on 4, 5, 12 and 13 January 1986.

## NUMBERS OF SIBERIAN CRANES

Counts of wintering Siberian cranes are listed in Table 1.

Date	Place	Number	Observer
Dec. 1981	Dahuchi, Sanshan Island	141	aerial survey (Zhou and Ding 1982)
5 Dec. 1982	Zhonghuchi	189	bird study group
6 Dec. 1983	Banghu	450	bird study group
15 Feb. 1984	Dahuchi	840	Liu Zhiyong
12 Feb. 1985	Dahuchi	1,428	Ding Tieming
5 Jan. 1986	Dahuchi	1,784	Liu Zhiyong

**Table 1.** Maximum counts of Siberian cranes at Poyang Lake.

## ACTIVITY PATTERN OF SIBERIAN CRANE FLOCKS

### Times of Occurrence

The timing of Siberian crane migration is closely related to the changes of local temperature at the time. If cold weather appears earlier in the north, the Siberian cranes will fly south earlier. Small numbers of Siberian cranes can be seen at the end of October and the beginning of November at the lakes of higher terrain, such as Dahuchi, Banghu, and Zhonghuchi. The number observed ranges

from 7-207. Large flocks of Siberian cranes arrive at Dahuchi, Banghu, and four other lakes by the end of November. From the end of December to the middle of March next year, the cranes gather into large flocks of around a thousand at Dahuchi, Banghu, and Dachahu to look for food and to roost. They stay there until the time to migrate north in March. Occasionally, some Siberian cranes are seen foraging at other lakes, but they never roost there.

#### Short Distance Flights on the Wintering Ground

The places where Siberian cranes roost and look for food have a relatively stable regularity for periods of 10-20 days, according to the changes of water level for each lake. If not disturbed, cranes either look for food and roost at the same lake every day during a period of time, or look for food at one lake (e.g., Dahuchi) and roost at another (e.g., Banghu or Dachahu). They will leave immediately and change the places of foraging and roosting if disturbed by human activities such as fishing or burning grass. Besides food and water levels, human disturbance is the main factor causing Siberian cranes to change their foraging and roosting sites and to make short flights.

#### Large Foraging Flocks

Large flocks of Siberian cranes (800-1,400) are normally seen foraging at one lake. They are composed of small groups of one or more families. The distances between these small groups ranges from 10-30 m. The whole foraging area often covers an area of 1-2 km<sup>2</sup>. The cranes will stop eating, look around, and call when people or animals approach. Cranes fly away immediately when disturbance is at a distance of about 400 m. Families of white-naped cranes *Grus vipio* are often seen among Siberian cranes. They like to look for food in the mud mounds dug up by Siberian cranes. Thousands of tundra swans *Cygnus columbianus*, geese *Anser* spp., and pintails *Anas acuta* can also be seen foraging at the same places. Thousands of feeding Siberian and white-naped cranes concentrated within a few km<sup>2</sup> is a unique habit of cranes at Poyang Lake Migratory Bird Reserve. Only a few scattered groups of 3-50 birds forage at smaller lakes such as Changhuchi and Xianghu.

### WINTERING HABITAT AND BEHAVIOR OF SIBERIAN CRANES

#### Feeding Habits and Food

According to our observation, the wintering Siberian cranes depend mainly on stems and roots of such aquatic plants as *Potamogeton malainus* and *Vallisneria spiralis*, accounting for over 90% of the crane's food. The Siberian cranes also eat small quantities of clams, small fish, snails, and grits. We examined a dead crane and found 53 g of stomach contents: 37 g of grits, 1.5 g of small snails, and 14.5 g of plant roots, feathers, fibers, and mud.

Siberian cranes mostly look for food in shallow water (a few of them look for food on muddy land in rainy weather).

Since plant roots and stems are small, Siberian cranes have to spend about 9 hours a day on foraging for themselves and their young.

#### Feeding Chicks

According to our whole-day observations on 4, 5, 12, and 13 January 1986, we found, in 20 5-min periods, that each of five families of Siberian cranes dug out food 7.67 times on average (minimum 3 times, maximum 10 times) and fed chicks 5.3 times (minimum 1 time, maximum 7 times). The female Siberian crane swallowed food 1-3 times, during which she fed their chicks 5-7 times. The male Siberian cranes swallowed food 2-3 times during which he fed chicks 1-3 times. Before early February, chicks did not dig for food themselves but just picked up food from the surface or from the parent's bill. They stayed near the parent and begged food with "quri quri" sound. When the parent was digging, the chick would gently tap the parent's neck. Sometimes the parent brought food up out of the mud and laid it on the surface, letting the chick pick the food up. After early February, the chicks began to dig food but not deeply like the parents. But often they could not find food. In early March, they could find food themselves, feeding beside their parents. Still the parent sometimes fed them. We found some single cranes looking for food and flying together with family groups. Whether they were subadults of these families or single cranes looking for companions needs further observation to verify. We also found that some young cranes drove away these single cranes.

#### Flight Movements

A Siberian crane runs four to six steps into the wind before it begins to fly. In a crane family, the male always flies ahead, the young crane in the middle and the female behind. Their flight altitude is about 40-100 m when they fly a short distance over a lake. Their black primaries will be exposed when flying, a really splendid sight! They land slowly on the ground with beak toward the wind. They put down their feet first, fold up the wings, and look around for a moment. The female digs food all the time after landing. The male will either call with the female first and then begin to dig food, or will be on guard. Young cranes like to follow their mothers.

If the weather is fine, between 1000 and 1300, a few to several dozen Siberian crane families will circle the sky over 10 times above a lake, calling sweetly. The circle diameter is about 40-50 m, at an altitude of 200-300 m. The circling lasts from a few minutes to over 10 min. The local people call this "circling clouds."

#### The Calls of Siberian Cranes

Siberian crane calls have several different sounds. Young cranes can only make the sound "ji-ji." The adults and subadults sound like "gru . . ." when startled. Parent cranes make the sound of "gei-gei" and "gi-gi" (female, higher pitch), as well as calling together, with alternate long and soft sounds of "fai" (male) and "mi" (female). This last call



occurs when the pair are in conflict with other families or after they have driven away the other cranes. Their sounds will be sweet and soft when they are flying.

#### Dancing

Siberian cranes dance not only when they are courting, but also when they are at the wintering place, especially after the end of February when it is warmer, around noon or between 1500 and 1600. During these periods, hundreds of Siberian cranes will fly from the open water to the shallow lake edges where they will preen and rest. The density of cranes at this time is much higher than during foraging, but lower than during roosting. The distance between two crane families is only about 2-3 m. Young cranes like to run and flap their wings and jump on the ground, or throw their food with their bills, or run after each other.

#### Roosting

Siberian cranes like to roost in very shallow water (under 30 cm) of a vast lake with very little disturbance. According to our observation on 4, 5, 6, 12 and 13 January 1986, Siberian cranes began to leave the feeding place at 1700 in groups of 3-7, or 5-18 birds, and fly toward the center of the lake.

Cranes are highly dispersed when they are looking for food during the day, but are very concentrated when roosting. They stay much closer to each other when it is raining, snowing and windy. They will be facing the wind in 2-6 groups of streamlined shape, each group containing several dozen to several hundred birds in order to cut down the force of the cold winds. When the evening comes, they fly to their roosting area in groups of 3-5 and continue looking for food. Half an hour after dark, Siberian cranes and white-naped cranes will begin to cry in one voice which can be heard far away. After another half an hour, they will quiet down and form a roosting pattern of 300 m long and 120 m wide, with heads close to the tails of the neighboring birds. At night, cranes are facing the wind, shrinking their necks, putting their heads under their wings and standing with one leg. The local people told us that old cranes are on guard until midnight while other cranes are roosting. Hunters in the past usually captured cranes after midnight when they were deeply asleep. Cranes will not roost in the same place again after they are disturbed.

At 0635-0755, the cranes wake up slowly and begin to preen, look up and stretch their wings. If it is freezing, they will postpone their morning feeding time until 1000 when the sun is shining on the lake. They will then fly from their roost in groups. When warm, cranes form a roosting pattern of over 400 m long and over 200 m wide in streamlined shape and will leave their roost shortly after dawn (around 0635) in groups. Every 1-10 min, a group of up to two dozen birds will fly away. Only a few crane families (about 100-200 birds) will stay at the roost and look for food.

#### Migrating North

Siberian cranes begin to leave for their breeding grounds between the end of February and mid March when the temperature goes above 10° C. Poyang Lake during this period is rainy and its water level rises. The cranes will choose a sunny or mostly sunny day to begin their journey north, between 1100 and 1200.

For example, we observed that the number of Siberian cranes went from 1,500 down to 1,100 between the end of February and mid March, 1986; the Siberian cranes had begun their migration. The departure takes about half a month, primarily in mid and late March. The most magnificent view of Siberian cranes' mass departure at Poyang Lake was on 19 and 22 March 1986.

Part of the Siberian crane population flies north through Zhalong in Heilongjiang Province and passes through a vast area of the Soviet Union to arrive at their breeding ground in Yakutia, in northeastern Siberia (Johnsgard 1983). Probably there are new breeding areas of Siberian cranes not yet discovered.

#### Appearance of Young Cranes

The color of a young crane's legs and bill are brown in the first year. The color of its feathers is partly brown; 20% of these young cranes' feathers will become almost completely white by February of the next year. At this time, they look the same as adult cranes when observed from 1 km away. We found, however, that less than 20% of the young birds will still appear almost completely brown after a long winter. There is very little change in their feathers. The reason for this difference in plumage still needs to be studied.

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# CRANES WINTERING AT EAST DONGTING LAKE

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## ABSTRACT

This paper presents preliminary results of an investigation on numbers, habitat, feeding and migration of Siberian cranes *Grus leucogeranus*, white-naped cranes *G. vipio*, hooded cranes *G. monacha*, and common cranes *G. grus* wintering at Dongting Lake. We observed cranes wintering at East Dongting Lake of Hunan Province during the winters of 1985-86, 1986-87 and 1987-88.

## NATURAL ENVIRONMENT

East Dongting Lake is on the south side of the Yangtze River, and on the east side of Dongting Lake, at  $29^{\circ} 07' 29''$  N and  $112^{\circ} 48' 113'' 05'$  E. The whole lake lies within the City of Yueyang. The Nature Reserve for Waterfowl was established in 1984 (see Figure 1). It covers an area of about 151,000 ha, including open water 93,000 ha, grassy marshland 20,000 ha, and mudflat 12,000 ha. There are annual wet and dry seasons in the area, with the wet season from May to October. During the dry season, 50,000 ha of open water area change to mudflat. The climate is categorized as a transition between the mid-subtropical zone and northern subtropical zone, with an annual average temperature of  $17^{\circ}$  C and water temperature of  $17.5^{\circ}$  C. The vegetation type is composed of grass marshland and aquatic marshland. It is a major wintering ground for waterfowl in the middle reaches of the Yangtze River. In this area, there are 114 fish species, 40 shellfish species, more than 140 bird species and 400 plant species.

## METHODS

We first used transects to search for cranes. After finding cranes, whole-day observations started. During observations, we recorded species, number of families and young. The duration of surveys were 15-30 December 1985, February 1987 and December 1987.

## NUMBERS OF WINTERING CRANES

There are four species of cranes wintering at East Dongting: Siberian, white-naped, hooded, and common cranes. In December 1985, we counted a total of 87 cranes: 2 Siberian cranes, 6 white-naped cranes, 59 hooded cranes (45 adults, 14 young), and 20 common cranes. The census in February 1987 found a total of 352 cranes: 18 Siberian cranes (14 adults, 4 young), 157 white-naped cranes (145 adults, 12 young), 120 hooded cranes (109 adults, 11 young),

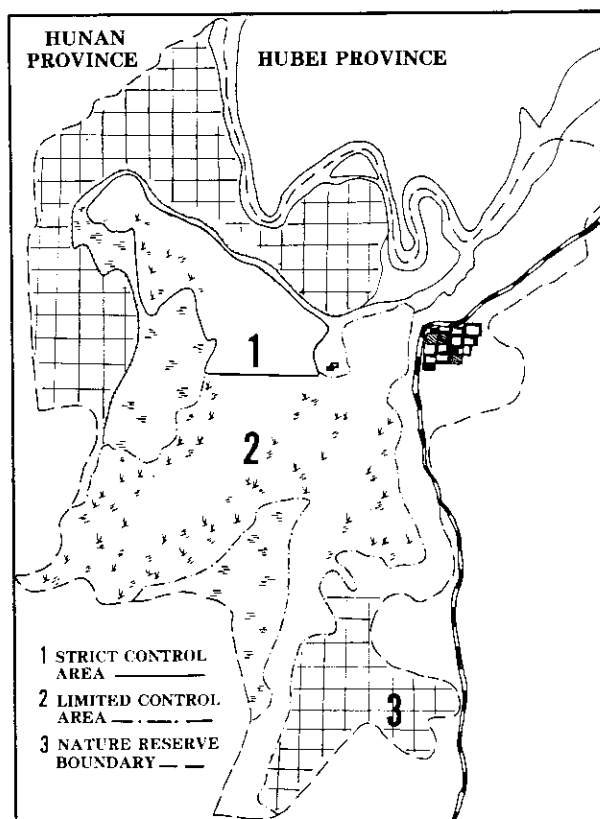


Figure 1. East Dongting Lake Nature Reserve.<sup>a</sup>

<sup>a</sup>the three management zones indicated on the map were established in 1990.

and 57 common cranes. In the December 1987 census, we found a total of 128 cranes: 3 Siberian (1 young), 54 hooded (10 young), 71 common (9 young). As indicated in Table 1, the largest numbers cranes were: Siberian cranes, 18 birds; white-naped cranes, 157 birds; hooded cranes, 120 birds; and common cranes, 71 birds.

Species	Number	Juvenile	Site	Habitat	Date
Siberian Crane	2	0	Pingqiao	mudflat	20 Dec. 1985
	18	4	Meitanwan	marshland	5 Feb. 1987
	3	1	Haohu	mudflat and shallow water	23 Dec. 1987
	3	1	Qixinghu	marshland	25 Dec. 1987
White-naped crane	6	?	Daxihu	marshland	20 Dec. 1985
	157	12	Jianxin	farmland	5 Feb. 1987
Hooded crane	59	14	Jianxin	farmland	22 Dec. 1985
	90	?	Jianxin	farmland	4 Feb. 1987
	120	11	Jianxin	farmland	5 Feb. 1987
	3	1	Jianxin	farmland	23 Dec. 1987
	54	10	Jianxin	farmland	24 Dec. 1987
Common crane	20	?	Jianxin	farmland	22 Dec. 1985
	57	?	Jianxin	farmland	5 Feb. 1987
	71	9	Jianxin	farmland	24 Dec. 1987

Table 1. Number of cranes wintering at East Dongting Lake.

#### HABITAT AND FEEDING

Wintering cranes roost on the exposed mudflats in the northwest part of East Dongting Lake, and never stay overnight in standing water. They fly back to their roosts in a large flock before dark, about 1630. Except for Siberian cranes which feed in the lake, cranes feed in rice fields, often with ruddy shelducks *Tadorna ferruginea*. They look for food actively in the morning from 0900 to 1100 and have a rest at noon on a mudflat at the edge of the lake or in shallow water. They feed on *Vallisneria spiralis*, as well as fruit and tender buds of *Carex unisexualis*, *Potamogeton malainus*, and *Phalaris arudinacea* growing on the marshland. In the rice fields, the main food for cranes is rice remaining after the harvest. We did autopsies on three hooded cranes that were poisoned and analyzed the matter in the stomach (see Tables 2 and 3). Their main food was rice.

	Wet Weight	Dry Weight	Rice	Husk	Sand	Snail Shell Fragments
1	61.0g	34.5g	15.5g	5.9 g	12.7 g	0.415mg
2	62.5g	29.4g	9.8g	7.3 g	12.3 g	0.423mg
3	62.5g	23.1g	11.0g	5.3 g	6.74g	5.123mg
Average	62.0g	28.9g	12.1g	6.17g	10.6 g	1.987mg

Table 2. Weight of food components in the stomachs of three hooded cranes.

	Rice	Husk	Sand	Snail Shell Fragments
1	44.0	17.1	36.8	1.2
2	33.3	24.8	41.8	0.1
3	47.7	23.0	29.2	0.1
Average	42.0	21.6	36.0	0.4

Table 3. Percentage of food components for three hooded cranes.

Siberian cranes live in shallow water and on marshland along East Dongting Lake, feeding on plant tubers and small amounts of clams and snails.

There are three kinds of flocks for wintering cranes. 1) Family groups. Family members fed, took breaks, preened, and roosted together. 2) Single species flocks. The flocks were seen when they flew to and from roosting places. Usually, the flocks were large, with a maximum of about 100 birds. In December 1985, 59 hooded cranes were found, which were divided into two flocks. 3) Mixed species flocks. Hooded and common cranes and ruddy shelducks often fed together.

#### MIGRATION

Siberian, white-naped, hooded, and common cranes migrate to East Dongting Lake in mid November and leave at the end of the following March. They stay for 130 days.

# THE WINTER ECOLOGY OF THE BLACK-NECKED CRANE IN CAOHAJ

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## ABSTRACT

The black-necked crane *Grus nigricollis* is a unique and rare bird in China. This paper reports observations of the black-necked crane's overwintering habits in 1975, and in the period from 1978 to 1985 at Caohai in Guizhou Province, China. The cranes arrived at Caohai in the middle ten days and the last ten days of October, and departed in the middle ten days and the last ten days of March next year. The overwintering period was about five months long. There were three kinds of groupings formed in the overwintering period: families, single species flocks, and mixed species flocks. The cranes' principal food was plants. The number of black-neckeds increased from 35 in 1975 to 305 birds in 1984, but decreased to 223 in spring of 1985. In Guizhou, the black-necked crane has also been discovered in Puan County to the southeast of Weining County. Puan is the farthest east region where the black-neckeds are distributed.

The black-necked cranes are rare birds in China, and primarily confined to this country. The plateau of Qinghai-Tibet is their main breeding place. Their overwintering at Caohai, in Weining of Guizhou Province, and some other localities has been studied by Zhou et al. (1980), Guo (1981), Lu (1983), and Li et al. (1985). This paper reports the results of our studies of the black-necked crane at Caohai in 1975 and the period from 1978 to 1985.

Caohai Lake is situated in the southwest of Weining Autonomous County, Guizhou Province, China, by the foot of Wumeng Mountain (see Figure 1). The geographic location is 26°49'26"53' N, 104°12'104"18'E. It is a freshwater lake which encloses an area of about 45 km<sup>2</sup>, retaining 1,400,000 m<sup>3</sup> of water. The bottom of the lake is 2,170 m above sea level; the average water depth measures 2 m, while the deepest area is 5 m.

The local people call the black-necked cranes "Cilou," black-headed wild geese and so on. Five male and two female specimens were collected in December and in January in the overwintering period. Their measurements were: weight 5,000-5,500 g, total length 1,140-1,200 mm, culmen 114.4-124 mm, wing 540-635 mm, tail 218-231 mm, and tarsus 231-253 mm.

## OVERWINTERING PERIOD

The black-necked cranes arrive at Caohai in the middle and last ten days of October and depart in the middle and last ten days of March next year. Table 1 indicates that the earliest arrival time at Caohai was 13 October 1982, and the latest departure on 11 April 1986; the latest arrival time was 11 December 1985, the earliest time that all birds had departed was 12 March 1979. Accordingly, the black-necked crane's shortest overwintering period was four months and twenty days, the longest about five months and ten days. Each year on average, there are about twelve days from

the earliest arrival date to the latest, and from the earliest departure time to the latest.

The cranes migrate in flocks of about twenty in a line or "V".

Year	First arrival date	Last departure date
1975	25 October	-
1978	20 October	-
1979	17 October	12 March
1982	13 October	18 March
1983	-	25 March
1984	18 October	-
1985	11 December	28 March
1986	-	11 April

Table 1. Overwintering period of the black-necked crane at Caohai.

## HABITS AND CHARACTERISTICS

The black-necked crane is alert, but not afraid of people who are even quite close. The writers have taken their pictures at a distance of 15 m, but the cranes were not frightened and did not fly away. They are especially tolerant of domestic animals. They usually feed with pigs, cows, horses, chickens and domestic ducks. But gunfire 100-200 m away will flush them. They run for three or four long steps, flap the wings and fly into the sky all at once, loudly crying "guga, guga."

When morning fog completely covers the surface of Caohai, the awakening crane groups begin to scatter all about. At 07:30, already after sunrise, the crane flocks begin to circle for several rounds and then disperse to the low-lying, wet places and farmlands around Caohai. Some of them fly far beyond Caohai and come back to the wetlands to rest at 1100. At 1500, they go out again to look for food

until sunset. But most of the cranes look for food all the day long and rest at the wetland. At night they roost in the wetland; now the flock is much larger. Some of the black-necked cranes roost with the large flock of common cranes *Grus grus*.

The roosting localities for the black-necked crane are indicated in Figure 1, in the low-lying areas and wetlands on the east and west sides of the water surface of Caohai, i.e., on the west side of Yangguan and Lolo Mountains and on the southwest and north side of Bajiazui. The cranes select wet areas for roosting, with little disturbance from the people.

The black-necked cranes are gregarious, assembling in three types of groups.

Family groups occur in the wetland and farmland. Each group consists of two to four birds, usually two adult cranes with one or two young birds, or sometimes one adult crane with one or two young birds. The young birds are completely dark grey. Some of them have not completely lost their down. They always closely follow the adult birds, and are easily recognized.

Single, same species flocks occur when the cranes are arriving or departing on migration, and especially when the cranes are looking for food or resting. They fly in a line. These flocks mainly consist of non-breeding cranes, and occasionally the family groups mingle with them. Often there are 30 cranes in a flock, but flocks of 120-150 have been observed occasionally.

Mixed flocks also occur, with common cranes and an occasional hooded crane *Grus monacha*.

#### FEEDING HABITS

The black-necked cranes look for food at Caohai in the low-lying wetlands, the farmlands and the vegetable fields nearby. If there are disturbances or ice or snow conditions, they may fly to dry lands far away beyond Caohai to eat. We have even observed four black-necked cranes foraging beside the forest 50 km from Caobai on 19 December 1978, and two family groups in the wheat fields 7 km beyond Caohai on 18 March 1983.

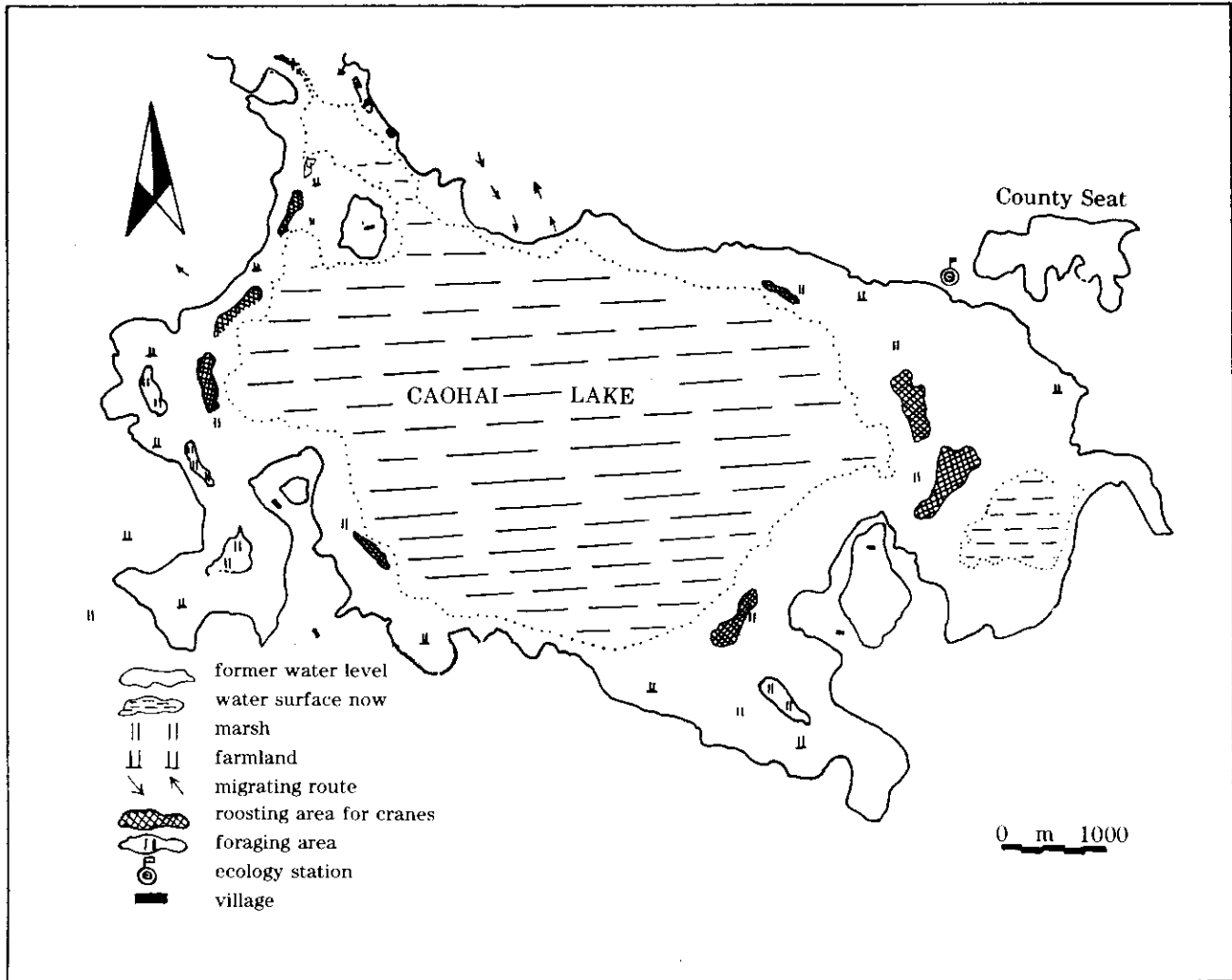


Figure 1. The wintering area for black-necked cranes.

Upon dissecting four black-necked crane stomachs in December 1978, and January and December 1979, we discovered tubers of *Scirpus yagara* in all of them. This sedge covers 70-80% of the lake, growing 40-50 mm high. It has a luxuriant tuber, with joints in the shape of big lumps, black in color and rich in starch. We also picked some kernel corn out of two of the four stomachs, food taken by the cranes after the harvest. We also found a few field snail's shells from one of the four stomachs. From the tracks left by the cranes when they forage, we know they picked leaves and roots of radishes and carrots, the stems and leaves of *Pedicularis resupinata* and the remains of sweet potatoes in the fields ploughed. Many circular holes about 10 mm were left after the cranes passed. Thus, the black-necked crane principally eats plants, with a little animal food in winter at Caohai.

#### NUMBERS AND DISTRIBUTION OF THE BLACK-NECKED CRANES

Many people have counted the black-necked cranes at Caohai. Everyone has used the same method for counting, because Caohai has smooth terrain with wide fields of view, and cranes have big bodies and are distributed in groups. Nevertheless, the counts vary due to differences in time (even in a single day), differences in the telescope used, and differences in the observer. Counts from eight winters are presented in Table 2. The number of black-necked cranes wintering at Caohai has increased from 35 in 1975 to about 305 birds in January 1984. During this period, water was artificially restored to Caohai, in the summer of 1982. The main reasons for the increase are: (1) Caohai's water area has expanded step by step, so that farmland returned into wetland, with great changes in the vegetation and increases in the cranes' food (it has been exceedingly important that the cranes have gained more areas for foraging and roosting); (2) fewer people were in the new localities, with less disturbance to the cranes; and (3) effective, direct protection methods, such as hunting prohibition, and provision of corn as food for cranes.

All of the black-necked crane counts in Table 2 are smaller than the real numbers at Caohai, because 3-5% of the total number of black-neckeds look for food far beyond Caohai.

Because of the scattered distribution of the black-necked crane breeding localities and the extraordinary remoteness of the Qinghai-Tibet Plateau, the black-necked cranes are virtually impossible to count in the breeding season. The black-necked cranes in the winter, however, are relatively concentrated and primarily occur in flocks. So it is feasible to count their numbers. Surely it is not appropriate to add together counts of cranes which are not from the same wintering period. But currently there is no alternative to achieve a minimum estimate for the entire species. There were 305 black-necked cranes at Caohai in January 1984. In the same winter there were 412 birds  $\pm 15$  in Tibet (Li et al. 1988). If we add 65 counted in Yunnan Province and 5 birds in Lijiang (Lu 1983) to the numbers related above, then the total number is about 787

birds. A number like this is only for reference. So far as we know, there were also more than 150 birds abroad in Bhutan (Gole 1989). Accordingly, a minimum estimate for the species is at least 900 birds.

About one third of this total winter at Caohai. According to the numbers now available, Caohai has the greatest number of wintering cranes and highest density (16.7 birds /km<sup>2</sup>). For this reason, the black-necked crane must be rigorously protected at Caohai and the research work strengthened. Caohai is not their only wintering place in Guizhou. Two specimens (kept at the Beijing Museum of Natural History, specimens #5756 and #5757) of the wintering black-necked crane have been collected in Puan County to the southeast of Weining 25°45' N, 104°56' E, height above sea level 1,500 m). This record represents the farthest east location for the black-necked crane to winter in China. We believe, however, that more wintering places will be discovered with further investigation.

Date	Number of cranes	Observer
11-12 November 1975	35	the authors
October-December 1978	45	the authors
5 March 1979	42	the authors
13 November 1979	84	the authors
3-13 December 1979	70-80	Zhou Fuzhang et al.
23 December 1979	85	the authors
December 1980	140	Lu Zongbao
December 1980	75	the authors
January 1981	73	the authors
February 1981	35	Gou Juting
December 1981	140	Lu Zongbao
8-11 December 1981	128	the authors
6-15 December 1982	296	the authors
29 January 1983	142	Wang Youhui
February 1983	291	the authors
March 1983	298	the authors, Pen Kuang
9-11 January 1984	317 ( $\pm 14$ )	Li Fengshan, Li Mingjing
9-13 January 1984	305	the authors
5-10 December 1984	269	the authors
15-20 February 1985	246	the authors
26 February-4 March 1985	222	the authors

Table 2. Numbers of the black-necked crane wintering at Caohai.

#### DISCUSSION

The counts from eight wintering periods in Table 2 tell us that the increase and decrease of Caohai's black-necked cranes is great and the fluctuation is irregular. After Caohai was restored to hold water in 1982, the number in the following winter increased to 298 birds, 170 more birds than in the previous winter. Since then, the changes in numbers

have been too irregular to be caused by any actual increase or decrease in the total numbers of the species. Instead, we believe that the numbers of cranes wintering at the various wetlands in southwest China change from year to year, due to various artificial and natural factors. Comparing our counts from late fall and early spring, it is apparent that the wintering numbers at a site are fixed during that season. The wintering places are selected as soon as the crane flocks arrive at the wintering region.

The most important measure for the protection of black-

necked cranes at Caohai is the preservation of the wetland habitats needed by the birds. At present, there are more than 1,300 ha of low-lying wetlands in the dry season. All of them would be drowned if Caohai's water level were caused to rise because people wished to store more water in the lake. Then, the cranes would lose all localities where they roost and feed. Even if there were some wetlands left, these areas would be too close to the residential areas of people. For this reason, some of the water stored at Caohai in winter ought to be drawn off so as to give the birds more shallow areas for roosting and feeding in winter.

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## A PRELIMINARY STUDY ON THE WINTER ECOLOGY OF COMMON CRANES IN CAOHAJ

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### ABSTRACT

This paper reports on studies of common cranes *Grus grus* wintering at Caohai, Weining, Guizhou Province from 1982-84. In 1983, the number of common cranes was about 2,178. The earliest they arrived for the winter at Caohai was early October; the latest they departed was early April the following year. The wintering period was about 180 days. The cranes traveled in flocks and usually roosted together with black-necked cranes *Grus nigricollis* and other migrating birds. The common cranes' principal food was plants, especially rhizomes of the sedge *Scirpus yagara*, corn, potatoes, radishes, and carrots.

The common crane is one of the largest birds that winter at Caohai. Common cranes used to be incorrectly regarded as black-necked cranes and were called "wild goose" or "cilou" by the local people in Caohai. The author made investigations of common cranes from 1982-84. This paper presents the results. For other accounts of this species, see Yang (1982) and Wu and Wang (1986).

### MEASUREMENTS

We measured four specimens of common cranes collected on 27 January 1983: the weight was 3,100-4,400 g, the total length 1,100-1,240 mm, the wings measured 554-570 mm, the culmen 103-106 mm, the tail 192-235 mm, and the tarsus 230-245 mm. After dissecting two females, we obtained 247 ova with a total weight of 1.1 g from one of the females. The largest diameter for an ova from this female was 5 mm. From the other female, we obtained 260 ova with a total weight of 1.2 g, and a maximum diameter of 3 mm. On the tertial feathers of a common crane, we obtained a large number of the ova of *Mallaphaga* of the family of Menoponidae. On one feather were 314 ova, one third of which had hatched.

### NATURAL CONDITIONS

The Caohai Lake is situated in southwest Weining Autonomous County, Guizhou Province, China, at the foot of Wumeng Mountain. The location is 26° 49' - 26° 53' N, 104° 12' - 104° 18' E. Caohai is a freshwater lake which encloses an area of about 45 km<sup>2</sup>, with 1,400,000 m<sup>3</sup> of water. The bottom of the lake is 2,170 m above sea level; the average water depth measures 2 m, while the greatest depth is 5 m.

### THE CLIMATE AT THE WINTERING GROUND

Common cranes winter from October to March. The Guizhou Weather Bureau notes the following conditions

for that period. The average temperature each month ranges from -0.9 to 11.7° C, the highest temperatures each month average from 4.8 to 20.9° C, and the average lowest temperatures each month range from -4.4 to 9.1° C. The earliest snow is 26 October, and the latest snow 4 May; the number of snow days is 1-10 days each month. Snow stays on the ground for 1-16 days each month; there are 6-29 snow days in a year, and the maximum depth of snow is 2-27 cm. Each month there are 2-27 foggy days. The average relative humidity each month ranges from 62-91%, and the precipitation each month ranges from 2.2-114.8 mm. The number of sunshine hours each month ranges from 84.7-241 hours. The greatest wind speed each month is 9.3-22 m sec, with most of the wind coming from the southeast.

### CONDITIONS OF MIGRATION

Common cranes winter at Caohai for about 180 days of the year. In 1982, the cranes started to arrive in Caohai on 18 October; the last day of departure was 31 March 1983. In 1983, they began to arrive at Caohai on 30 September; the last birds left on 4 April 1984. In fall, the size of the population increases day by day until mid November. The population remains rather stable from the last 10 days of November to the first 10 days of March. The departure period is from the second 10 days of March to early April, with the population decreasing day after day.

There is no definite time of day for the cranes' arrival in Caohai. They may arrive morning, noon, or night. There are more birds in departing flocks in spring than in arriving (autumn) flocks, which come in smaller groups and at different times. We observed eight flocks of cranes that arrived at the southwest corner of Caohai's Luoluo Mountain from 1030 to 1400 on 20 October 1982. The smallest group had 7 cranes and the largest 35. They did not hasten to land once they were in the sky over the lake, but first circled several times. After landing on the low-lying wetland, they kept still, alert to danger. At any unusual sound, they would fly up and circle before landing in a safer place.

The springtime departure of cranes is really a magnificent sight. The largest flock consisted of hundreds of birds, the smallest a hundred. They circle the sky shouting ceaselessly in a high-toned voice. People can see the groups and hear the voices from several li (2 li = 1 km) away. Cranes scattered around the lake, upon hearing the voices of the groups circling the sky, will fly up joining them for the outward flight. The comings and goings of crane groups last about two hours. At last, all the scattered birds are called to join the groups in the sky. Migration to the north has begun.

We observed one group of cranes flying over Jiangjiawan in the north of Caohai from 1005 to 1152 on 27 March 1983. This group flew off and came back again four times. Each time, common cranes on the ground flew up to join them. We counted 73 cranes the first time, and 87 more the next time, totalling 160 birds. The third time, there were 24 more joining, making 184 in all. The fourth time, only 3 cranes joined the group raising the total to 187. We suspect they joined a flock with a common destination. Groups coming from Xuanwei in Yunnan Province flew over Caohai without attracting the Caohai birds, perhaps because they did not share the same destination.

#### BEHAVIOR

Forty kinds of wintering birds stayed near common cranes at Caohai, including the black-necked crane, the bar-headed goose *Anser indicus*, the ruddy shelduck *Tadorna ferruginea*, northern lapwing *Vanellus vanellus*, and many kinds of plovers and sandpipers. Black-necked cranes and bar-headed geese usually roost, forage, and rest with common cranes in the same habitat. Common cranes scatter to look for food twice a day. First they go out from about 0800 to 1130. Around noon, they return to the low-lying wetlands to rest with heads under their wings and the tip of their beak inside the feathers. The second time they go out is from about 1500 to 1730. After 1800, most of the cranes roost close together. A few that have sought food far away come back to roost after 2100.

Common cranes appear in three types of flocks during winter: single families can usually be seen at feeding places, consisting of two adults with one or two young birds; one species flocks can usually be seen while migrating or roosting, with tens or even thousands of birds; mixed species flocks can often be seen in the wetlands early in

the morning or at noon. The mixed flocks usually consist of common cranes, black-necked cranes, ruddy shelducks, bar-headed geese, northern lapwings, eastern golden plovers *Pluvialis dominica fulva*, and so on. Especially snowy or foggy weather, more than a thousand cranes of various species often gather together.

Common cranes are alert and agile, and are sensitive to the presence of people. They are not afraid of farmers as close as 20-30 m away. They always carefully watch and avoid people, however, who are intentionally trying to come closer. When aroused, the cranes curve their necks to warn off intruders. To get away, they run two or three steps, then fly off. Young birds, not so vigilant, often fail to fly up with their family. The adults return to shout at them loudly.

Common cranes eat many things that pigs, horses, cows, and sheep have turned up from the earth.

#### NUMBER AND DISTRIBUTION OF COMMON CRANES

According to the statistics calculated in February and in the first 10 days of March 1983, the population of common cranes is stable. We counted cranes with a 15X telescope: the largest number was 2,324 and the smallest, 2,015. The average was 2,178 (see Table 1).

The winter feeding ground of common cranes is very large and includes farmland, vegetable fields, and low-lying wetland, with a diameter of more than 10 km. On a sunny day free from snow, fog, rain, or wind, the area is enlarged to the region outside of Caohai. The birds have looked for food on the farmland and swamps of Dongshan Township, 4 km south of Caohai; in the region of Baojia Sugar Plant, 7 km west of Caohai; near the Agricultural Science Research Institute, 2 km north of Caohai; and along the Jizhong Highway, 15 km east of Caohai. During the period before 1982 when water at Caohai had been drawn off, common cranes rested mainly at Dong Mountain, Luoluo Mountain, Yangguan Mountain, and Dajiangawan. Once water was restored to Caohai in 1982, the ecosystem was transformed. With some of the former roosting areas submerged in water, and some of them cultivated as farmland, the cranes moved to the southeast corner of Caohai and to the southwest corner along the lake. These new locations are low-lying wetland and farmland, where ditches, streams, and dense vegetation make it difficult for people and livestock to come.

Location	2nd Middle School section	Weish section	Zhonghoshuai mud mark	Jiangjawan section	Yangguanshan section	Loloshan section	Gujahazi	East of Bejaznei	Total
<b>Time</b>									
Feb. 1, 11:45 - 12:30	272	253	417	206	11	278	450	194	2081
Feb. 4, 13:12 - 14:05	184	361	613	82	36	195	436	108	2015
Feb. 29, 16:26 - 17:20	13	52	786	456	0	137	501	347	2292
Mar. 8, 11:25 - 12:20	49	226	344	271	96	348	472	518	2324
Average	129.5	223	540	253.75	35.75	239.5	464.75	291.75	2178

Table 1. Numbers of common cranes in winter at Caohai, 1983.

## FEEDING HABITS

We studied the feeding habits of common cranes wintering at Caohai by dissecting their stomachs and by direct observation in the feeding area. Their principal food is plants, such as corn, beans, peas, potatoes which remain in the field after harvesting, and wheat *Triticum aestivum*, radishes *Raphanus sativus*, carrots *Daucus carota*, and cabbages *Brassica chinensis* before the harvest. They also eat spinach which is planted in the vegetable fields and the roots of water onions *Scirpus tabernaemontani* and sedges that are growing in the wetland. Their main animal food is soft-bodied animals such as field snails *Cipangopaludina cathayensis*, *C. ventricosa*, *Bellanya aeruginosa*, and *B. purificata*. These plants and animals are rich in starch, fat, and protein. This diet increases the cranes' ability to survive bitter cold or occasional food shortages. Common cranes have a strong digestive system which helps them through the winter. Their feces contained no undigested food nor any gravel. The feces color is dark green and sometimes has white spots. Cylinder-shaped, it is 40 mm long and 10 mm in diameter, resem-

bling feces of the goose. Cranes can swallow a piece of plant root as big as a man's middle or little finger. They can eat a mud-like gravel that is 17 mm long, 12 mm wide, and 12 mm high. According to the analysis of four stomachs dissected, the stomach contents include 68.9% plants, 1% animals, and 30.1% different kinds of gravel (see Table 2).

## DISCUSSION

Common cranes are concentrated in the region of Caohai. Large flocks of common and black-necked cranes roost together in winter. These two species belong to the same genus and exhibit similarities in winter ecology and behavior (see Wu et al. this proceedings), but we never saw aggression between them.

When the weather is warm, the common cranes feed in the wetlands. Cold weather freezes the water, however, and the cranes are forced to feed in farmland, destroying many vegetables. Then local people try to chase the cranes away, using dogs, or catch the birds with traps or poison them. The reserve staff have tried to stop this persecution, but have not yet succeeded.

Number of dissection	Weight of stomach (g)	Net weight of food (g)	Weight of plant food (g)	Weight of animal food (g)	Weight of gravel (g)
1	300	125	90.0	1.0	34.0
2	275	110	72.3	0.9	36.8
3	284	111	77.2	1.3	32.0
4	290	114	77.0	1.5	36.5
Average %		115	79.25 68.9%	1.18 1%	34.76 30.1%

Table 2. Stomach contents of common cranes in winter at Caohai.

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## ON THE MANAGEMENT OF CAOHA1, GUIZHOU PROVINCE

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### ABSTRACT

Caohai is one of the most important wintering areas of the black-necked crane *Grus nigricollis*; a number of common cranes *G. grus* and several hooded cranes *G. monacha* also spend the winter. Through making four year's preliminary investigation on Caohai (1982-1985), we present the following opinions about management of this area.

### A SURVEY OF CAOHA1

Caohai is situated in Weining County, northwest Guizhou Province, 26° 48' 26" N and 104° 9' 104" 18' E, and is the greatest natural fresh water lake of Guizhou Province. The bottom of the lake is 2,170 m above sea level. This lake receives the drainage of five major rivers: Baima, Beimen, Maojiahaizi, Dongshan and Dazhong Rivers. Summer is not very hot and winter is not very cold. It is wet in the summer and autumn and dry during spring and winter.

Aquatic plants are abundant. There are a total of 37 species of aquatic vascular plants (Yuan 1986). Dominant species are: *Scirpus validus* and *S. yagara* belonging to the emergent plants; *Polygonum amphibium* and *Trapa nitzus* var. *bispinosa* belonging to floating leaved plants; *Ceratophyllum demersum* and *Chara* sp. belonging to submerged plants; *Myricophyllum spicatum* and *Marilea quadrifolia* belonging to floating plants.

Caohai is rich in animal resources. There are nine species of fish, including *Carassius auratus*, *Cyprinus carpio* and *Pseudorasbora parva*. Over one hundred tons of fish can be harvested each year. There are 33 species of amphibians and reptiles in Caohai and its adjacent area, including *Bufo bufo gargarizans*, *Rana weiningensis*, *Oreolalax rhodostigma*, *Japalura varcoae* and *Natrix johannis* Li (1986). There are 100 species of birds — the three species of cranes mentioned above, black stork *Ciconia nigra*, white stork *C. ciconia boyciana* which are first-class protected species by the state, bar-headed goose *Anser indicus* and ruddy shelduck *Tadorna ferruginea*, etc. which are of great economic value, as well as 48 species of migratory birds that are listed in the *Sino-Japanese Conservation Agreement on Migratory Birds and Their Habitats*.

Caohai Nature Reserve includes 870 ha of marshlands, 2,488 ha of water surface, and 1,255 ha of farmland. The types of farmland are hillside and plain. The area of the latter varies as seasons alternate. The main crops are corn, potato, buckwheat, Chinese radish, white radish, and pakchoi. Among them, corn and potato are staples for the local people. Livestock and poultry are mainly sheep, oxen, pigs, ducks, chickens, and geese. Weining is one of the poorest counties in Guizhou Province.

### CHANGES AT CAOHA1

According to historical records, in the spring of 1857, it rained for 40 days and nights. Torrents of water rushed down the mountains and water paths of undercurrent were silted up, and then Caohai was formed. Great changes have taken place since the formation of Caohai. Because of drought, the water surface of the Caohai area covered less than 2,000 ha in 1941. At the end of the 1940s, however, the water surface covered 4,500 ha. In the early and mid-1950s, it covered about 3,800 ha. Beginning in 1958, water drainage and destructive felling of trees destroyed Caohai seriously. About 700 ha of new farmland were formed as a result of drainage in 1958. A greater drainage project occurred in 1970-1971, using over 1.5 million man-days of labor, costing more than 1.3 million yuan (\$350,000). By the end of 1971, the water in Caohai had all been drained. In 1956, forest coverage around Caohai was 35.8%. But, in 1982, it was only 13.7%!

Because of the reduction of forest and lake area, the environment worsened quickly. During the seven years before Caohai Lake was drained (1966-1972), mean annual temperature was 10.4°C and during the seven years after the lake was drained (1972-1979), mean annual temperature was 10.2°C. Annual precipitation was reduced by 45.7 mm and the number of days with strong wind over force 7 during April and May every year increased from two to five. The ground water level decreased so that it was very difficult for local people and livestock to obtain drinking water.

The newly opened farmland furthermore was disappointing. The central part of the lake is low and its bedrock is marlite and coal-bearing series; more than 1,300 ha of the central lake area became marshlands not fit for farming

<sup>1</sup>This data is quoted from Caohai planning documents prepared by the Forestry Bureau of Weining County in 1982. According to the documents, the planned area of Caohai Nature Reserve then was 15,272.8 ha, and its location was 104° 17' — 104° 34' E, 26° 65' — 26° 78' N.

at all. In addition, bare slates occupied nearly 340 ha, so farmland occupied only about 1,300 ha. The farmland that ensured stable yields despite drought or excessive rain was merely 100 ha. Crops did not grow well on most of the farmland as a result of barren topsoil over the peat. On that land, crops suffered drought in early spring and waterlogging in the summer rainy period (Jin and Wang 1980). In 1978, only 850 tons of potatoes, corn, and wheat were harvested worth about 170,000 yuan (\$45,000).

The survival of cranes was affected by the constantly and drastically changing environment. According to local elderly people, during 1930s-1940s the population of cranes was so large that cranes even moved about along both sides of the Qiantian (Guizhou to Yunnan) Highway. Though the cranes are called fairy cranes and are considered a symbol of longevity, the local people also think that one might gain longevity by eating cranes; thus, the hunting of cranes was popular. The local *Miao* people have had the tradition of hunting for centuries, and they set traps along the ditches on farmlands at dusk and night to hunt wild ducks and geese. Occasionally, some cranes are caught too. The phenomenon of destroying animal resources still occurred after the government designated cranes as protected animals. Nevertheless, the more serious effect on cranes was the drainage project. During the period when Caohai Lake was drained, counts were made of black-necked cranes. The maximum number was less than 150 and the minimum only 35 (Wu and Li 1985). In 1982, the government of Guizhou Province made a decision to restore Caohai and built a water-flow dam 2,171.70 m above sea level and 8 km from the Town of Weining, dividing the former Caohai Lake into northern and southern parts. Though the purpose of the dam was not mainly for protecting cranes, the rise of the water level and expansion of marshlands provided a favorable condition for cranes. In the same year, the provincial government published the *Measures of Protection and Management of Wildlife Resources in Guizhou Province*. The black-necked crane was listed as a first-class species protected by the state. There were also protective measures by the provincial government for common cranes which are listed in *The Sino-Japanese Conservation Agreement on Migratory Birds and Their Habitats* (because hooded cranes had not been found then, their classification of protection was not specified). Since then, the population of cranes has increased steadily. In January 1983 and March 1984, the population of black-necked cranes was  $317 \pm 14$ ,  $332 \pm 19$  respectively. On 21 January 1984, the Fifth Session of the Standing Committee of the Sixth Provincial People's Congress endorsed *The Decision on Several Issues for Policy for Enlivening Forestry Economy in Guizhou Province*. Caohai was designated as a nature reserve according to the 18th article of the document.

From the beginning of Caohai's restoration to 1986, the distribution of cranes was not stable due to the constant change of micro-environments. In 1980 and 1982, cranes were more concentrated in the area between the lake and the foot of Luoluo Mountain (there are very large marshes in this area, the nearest distance between the lake and mountain is about 500 m) (Li and Li 1985; Zhou et al. 1980).

In the winter of 1983, owing to rising water levels and expansion of the lake surface, marshlands and farmland around the lake were greatly different from the previous year. To the east of the lake, a very large marshlands formed. Furthermore, some of the farmlands around the marshlands were vegetable fields and unplowed corn fields. Cranes were mainly seen in Zhonggou and the Erdao River east of Caohai, and in Baijiazui, southeast of Caohai. To the west of Caohai, however, from Luoluo Mountain to Yangguan Mountain at the northeast corner of the lake, the soil was plowed and marshlands almost disappeared (the nearest distance between the lake and the foot of Luoluo Mountain was only about 200 m). Only a few cranes were seen there.

## SUGGESTIONS

Caohai is a natural fresh water barrier lake. As early as the Pleistocene, Caohai had already had the Karst structures of underground cracks and falling water caves. It took a long long time to form the Caohai Lake as it is today (Qin 1986). In order to protect such a vulnerable ecological environment for the cranes, we make the following proposals.

### The Underlying Management Principle for Caohai Nature Reserve

Caohai is one of the wintering area where black-necked cranes are most concentrated, reputed as a "bright pearl" on western Guizhou plateau because of the existence of cranes. Protecting cranes and their habitat is the most fundamental reason for setting up Caohai Nature Reserve. Precisely because of this, maintaining the crane's living conditions should be a prerequisite for all activities in Caohai. Economic exploitation should not be based on destroying the crane's habitat, but on improving the crane's habitat and upgrading the living standard of the local people.

### Maintaining the Present Quality and Quantity of Water in Caohai

Caohai Lake, with many villages around it, is in the suburbs of the Town of Weining. The lake is surrounded by three major highways — Weining-Zhaotong Road, Weining-Xuanwei Road, Weining-Shuicheng Road and several county back roads on which human activities are frequent. Therefore, if the area of lake is expanded, marshlands will be pushed toward the roads, villages, and the edge of the town, and the area of marshlands will become smaller. Cranes would be affected seriously. Accordingly today's area of lake water surface should be retained, at between 20 and 25 km<sup>2</sup>.

Another threat to Caohai is soil erosion and deposition of the remains of aquatic plants at the bottom of the lake. According to calculations, it is possible that the whole lake will become marshlands in 50 years if current trends continue (Deng et al. 1985), the catastrophe of the 1950s and 1970s might return.

Therefore, a basic task to protect cranes and their habitats is to afforest waste hills around the lake and on

the banks of the five rivers flowing into the lake, to renovate the woodlands, and even to close hillside paths to facilitate afforestation. We ought to plant mostly shelter trees, selecting the tree species with big crowns, thick branches, well developed roots and long life. At the same time, we can plant some trees on the flatland and gentle hillsides for timber and other economic purposes in order to improve the living standard of the local people.

In order to alleviate and eliminate the deposition of aquatic plants at the bottom of the lake, fishing management should be reinforced. When catching some species of fish and hunting some waterfowl with great economic value, we should not only consider carefully their population growth and decline and their affect on the cranes, but also their control over growth of aquatic plants.

#### Management and Utilization of Farmland and Protection of Marshlands

With the recovering of water levels, the population of cranes has been increasing in Caohai. Some cranes often fly out of Caohai to nearby farmland looking for food (mainly in corn fields on the hillsides). It is very common for cranes to look for food in harvested farmland in Caohai, especially at dawn before peasants go to the fields. Cranes eat corn and many kinds of vegetables. Crops now make up a large part of the crane's diet, probably becoming a necessary component. Therefore, in Caohai Nature Reserve, the management office may buy some farmland (or crops on farmland) to provide food for the cranes. In the meantime, it is necessary to persuade local people not to plow the soil on other unbought farmlands until spring, so that cranes can find food on the soil surface; if plowed immediately, the food will be buried. In addition, the management office may subsidize local people to grow some assigned crops to meet the cranes' needs of various nutrients. It is also desirable to designate some areas for artificial feeding on a limited basis, to supplement other foods during the coldest weather.

In order to expand the area of farmland, however, the local people are "nibbling" away the marshlands by digging deep ditches and heightening the level of fields. The marshlands at the foot of Luoluo Mountain has almost disappeared. Marshlands is the most important habitat providing animal and plant foods for cranes (Li and Li 1985; Wu and Li 1985). Areas of marshlands should not be further reduced. Therefore, we should strictly forbid all activities turning marshlands into farmland in order to guarantee the protection and development of aquatic plant resources.

There are large numbers of domestic fowl and livestock on the farmland and marshlands. Excessive numbers of livestock will affect the growth of aquatic plants; domestic fowl and wild waterfowl living together will increase the incidence of infectious disease among wild waterfowl. We must at once control the numbers of domestic fowl and livestock in Caohai, and strictly quarantine domestic fowl.

#### Scientific Research

Wetlands help regulate the hydrological cycle and pro-

vide habitat for plants and animals, especially waterfowl. As a wetland, Caohai has these two functions. As mentioned above, climatic change around the period of drainage has shown the role of Caohai in regulating the hydrological cycle. Caohai provides a good living condition for waterfowl, including cranes. The crane is a sensitive "barometer of the environment" and "indicator species" for the wetland community. From the formation of Caohai to present, a series of changes, including both man-made and natural ones, have taken place. Very little information, however, has been derived from these changes. At present, the technical expertise of the Caohai Ecology Station of Guizhou's Academy of Science, and the Management Office of Caohai Nature Reserve is very weak. It is urgent to strengthen the two units' technical staff and carry out international cooperation extensively so as to enhance our monitoring ability. We need to find out the relationship among lake water, marshlands, water plants, and waterfowl, and to provide reliable scientific information on managing and utilizing the wetland. Caohai's long-term future depends on scientific research.

#### Life of the Local People

Ideally, Caohai would be a research site where human interference is non-existent. But, Caohai cannot reach this standard now or for the near future. Research data will be seriously affected by activities of local people. Indeed, we must consider the life of the local people who live in one of the most economically depressed counties.

Improvement of the living standard of the local people ought to be realized by the following means: upgrading the utilization ratio of current farmland and grazing land that cranes do not use; extensively improving existing farming methods, and letting the local people participate in some activities of the reserve. Along the borders of the reserve, conflicts between the reserve and local activities outside the reserve may be solved by establishing a protected area in which only limited exploitation is carried out (a buffer zone). In planning this buffer area, we ought carefully to consider its size. If the size is too small, the buffer will not eliminate conflicts; if the buffer is too large, the reserve will lose its basic function.

Now many people wish to develop livestock and tourism. Major development of livestock farming and duck breeding is obviously not feasible in such a small Caohai area. Transportation is not convenient, especially in the winter season for crane watching. Other facilities are not well developed either, and Caohai is surrounded by waste hills. Therefore, the feasibility for tourism at Caohai must be closely scrutinized.

The most important point we should be aware of in considering Caohai economically is its function to stabilize the local ecosystem, a critical benefit for agriculture. The catastrophe of overdeveloping farmland, at the expense of wetlands, has already been experienced. We should not put undue emphasis on economic exploitation, because it is very possible that we would end up putting in large amounts of capital once more to regulate (or restore) Caohai's ecosystem.

## ACKNOWLEDGMENTS

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## THE DISTRIBUTION AND HABITATS OF THE CRANES IN YUNNAN PROVINCE

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### ABSTRACT

This paper is based on the records of field investigations from 1958 to 1987 by the Ornithology Department of our institute and notes from other sources. There are four species of cranes in Yunnan Province: common crane *Grus grus*, black-necked crane *G. nigricollis*, red-crowned crane *G. japonensis*, and sarus crane *G. antigone*. The locations where cranes have been observed, the resident time, and the population sizes for these four species are summarized for Yunnan Province. Suggestions for the conservation of cranes have been made in this paper.

### DISTRIBUTION OF CRANES IN YUNNAN PROVINCE

The distribution of the four species of cranes is shown in Figure 1.

#### Common Crane

**Early Records:** Captain Wingate obtained an adult crane near the City of Yunnan (now the city of Kunming) in February 1899. Bangs and Phillips recorded an adult from Mengzi; Monsieur Pichon obtained one adult bird; and Mr. La Touche recorded this species as being abundant around Mengzi and the near vicinity in winter, arriving in late September (Rothschild 1926). An adult crane was obtained from Tengchwan on 21 December 1933 (Stone 1933).

**Recent Records:** Localities where observations of common cranes are recorded include: the swamp near Dianchi Lake, City of Kunming (30 November and 5 December 1960); Yangjie, Songming County (27 December 1961); Qiaojia County (25 November 1963); Datun Lake, City of Gejiu (winters from 1971-1978, according to records of Yang Dehua, 1982); Napahai Swamp, Zhongdian County (5-6 December 1984); Lashihai Swamp, Lijiang County (14-16 December 1984); and Huize County (6-9 January 1987).

#### Black-necked Crane

**Early Records:** Captain Wingate obtained an adult crane near the City of Yunnan in February 1899 (Rothschild 1926). Two black-necked cranes were captured on 20 March 1929 at Yungning, Yunnan (Bangs 1932), and two females from Yungning Plain, Yunnan, December and January 1931 (Riley 1931).

**Recent Records:** Recorded localities include: Napahai Swamp, Zhongdian County (3-5 December 1984); Lashihai Swamp, Lijiang County (14 December 1984); Lugu Lake, Ninglang County (4-7 February 1983, according to records of Wu et al. 1985); and Huize County (6-9 January 1987).

#### Red-crowned Crane

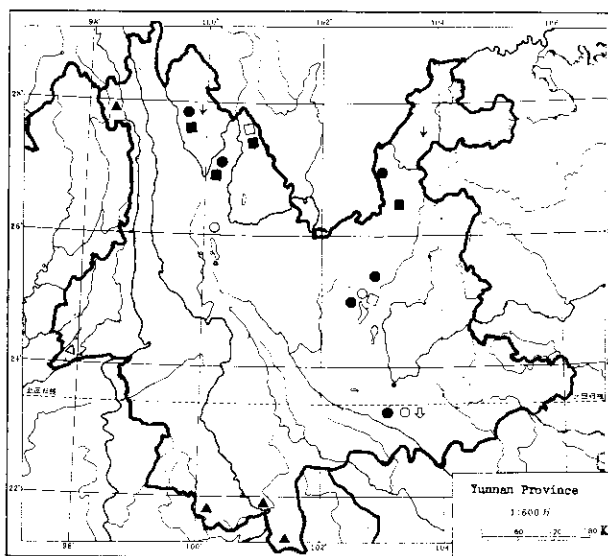
**Early Records:** Mr. La Touche recorded sightings of this species on the Mengzi Plains (Rothschild 1926).

**Recent Records:** Recorded localities include: Zhaotong County (4 December 1963 and 8 March 1978), and Napahai Swamp, Zhongdian County (winter 1980, according to the records of Wang Zijiang).

#### Sarus Crane

The eastern subspecies *Grus antigone sharpii* occurs in Yunnan.

**Early Records:** Anderson obtained two specimens at Tsitkaw in March 1868 and 1875. He also saw a flock totaling over 600 at Ponsee (both Tsitkaw and Ponsee are on the China-Burma border in western Yunnan).



**Figure 1.** The distribution of four species of cranes in Yunnan Province.

- ● Common Crane *Grus grus lilfordi*
- ■ Black-necked Crane *Grus nigricollis*
- ◇ + Red-crowned Crane *Grus japonensis*
- △ ▲ Sarus Crane *Grus antigone sharpii*
- □ ◇ △ Early Records
- ■ ● + ▲ Recent Records

*Recent Records:* Recorded localities include Menglun (26 March 1959) and Mengpeng (28 February 1960), Mengla County; Menge (February 1960) and Mengzhe (9 February 1987), Menghai County; and Dongshaofang (August 1973), Gongshan County.

## OBSERVATIONS OF LIVING HABITS

### Seasons of Occurrence

The above records reveal when each crane species resides in Yunnan. Common cranes are observed from September each year to February of the next year. They either winter in the province or pass through.

Black-necked cranes are seen in the province in winter from December each year to March of the next year.

Red-crowned cranes have been seen occasionally in December or March. They pass through the province and were rarely observed.

Sarus cranes were found during February or March in Xishuangbanna Autonomous Prefecture of Dai Nationality in the southwest part of Yunnan, and they were seen nesting in April and May. The nest was made of a huge pile of straw, reeds and rushes. The eggs, normally consisting of a clutch or two, were greenish or greyish-white in color. Nests were found in a marsh in Xishuangbanna area and the nearby vicinity in 1959. Since then, sarus cranes have not been observed in that area.

### Size of Populations

Groups of more than 10 common cranes were seen from 1960 to 1978 wintering at Kunming, Songming, Qiaojia, Gejiu, and elsewhere. Groups of 10 and 80 were found on 14-16 December 1984 at Lashihai of Lijiang County. On 6-8 January 1987, seven groups were found, numbering 4, 11, 16, 24, 34, 86, and 107 birds in the hilly cultivated land around Daqiao Reservoir and Changhaizi Reservoir of Huize County. According to observations, there were formerly about 141-149 common cranes wintering in Yunnan Province. Since 1970, the number of common cranes has been greatly decreasing in the central and southern parts of Yunnan Province.

Black-necked crane population statistics for Napahai Swamp of Zhongdian County are shown in Table 1, based on the results of investigations conducted between 0800 and 1700 from 3 to 5 December 1984.

The basic group composition usually contained two adults and one young bird, i.e., a family unit. Larger groups were a result of many small families and single cranes moving around together. From 4-7 February 1983, a total of 45 black-neckeds were recorded at Lugu Lake of Ninglang County (Wu et al. 1985). On 14 December 1984, a total of 36 were recorded at Lashihai Swamp of Lijiang County. On 9 January 1987, a total of 211 were recorded in the hilly cultivated land around Changhaizi Reservoir of Huize County. According to these observations, it is estimated that the black-necked crane population totals more than 100 birds in Yunnan in winter.

Date	Flock Size	Total
Dec. 3	One group of 27, 3 groups of 3 each	36
Dec. 4	One group of 23 (15,9 and 6), 3 groups of 3 each	62
Dec. 5	One group of 26, 2 groups each of 7 and 4, one group of 3	51

**Table 1.** Flock composition of black-necked cranes at Napahai, 1984.

Red-crowned cranes, which are rare migratory birds in Yunnan Province, were found by accident at Zbaotong and Zhongdian.

Sarus cranes were first found at Tsitkaw and Ponsee by Anderson in March 1868 and March 1875. He saw a large group of 600 birds at Ponsee. More recently, the author observed two adults at Menglun, and a group of five to six at Mengpeng in March 1959 and February 1960. In February 1987, the author went to search again for sarus in the southwest part of Yunnan. But the sarus crane has not been observed during successive investigations in that area. It is said, however, that seven sarus cranes were found by local people at Mengzhe, Menghai County of Xishuangbanna on 9 February 1987. These birds probably strayed from Burma.

### Feeding Habits

Common cranes usually look for food on river banks, and in swampy and cultivated lands. Upon examining the stomach of a common crane collected from Qiaojia County, we found that it contained only sweet potatoes. We observed that the black-necked cranes were feeding on grass roots, insects and freshwater mussels in the swamps of Napahai of Zhongdian County. Sarus cranes look for food in cultivated lands. The examination of the stomach of a sarus crane collected from Menglun of Mengla County showed that it contained frog, earthworm, insects, and some grass.

## PRESENT SITUATION OF CRANE HABITATS

Crane habitat in Yunnan has changed tremendously in recent years, because most marshland has been cultivated. For example, about 2,380 ha of the marshland around Dianchi in the City of Kunming has been cultivated. The area of the marsh decreased from 25 km<sup>2</sup> to 8.3 km<sup>2</sup> (Yang and Li 1985). Other marshlands in Yanglinhai of Songming County, Changqiaohai of Mengzi County, and Datunhai of the City of Gejiu have also been cultivated. As a result of the decreased marshland area, crane habitats and the source of their foods have decreased. Also, the number of cranes has obviously decreased in Yunnan. Common cranes and black-necked cranes now are only seen wintering at Napahai of Zhongdian County, Lugu Lake of Ninglang County, and at Daqiao and Changhaizi Reservoirs of Huize County, all places where there is less human activity.

#### SUGGESTIONS FOR REINFORCING THE CONSERVATION OF CRANES

The first thing we should do is to launch an educational program to increase awareness for the need for nature conservation, especially the conservation of cranes and marshlands, and help the masses of Chinese understand that cranes are symbols of natural beauty for the common good of all. If we all agree to protect the cranes, we must also preserve those marshlands on which the cranes depend for their existence.

The second suggestion is to establish nature conserva-

tion organizations for the cranes and other wintering birds in Yunnan, and to strengthen the management of these organizations.

Thirdly, we suggest that our provincial authority of nature conservation designate areas in Yunnan, such as Luguhu Lake of Ninglang County, Daqiao and Changhaizi Reservoirs of Huize County, as nature preserves for black-necked cranes and common cranes, and strictly forbid hunting in these areas.

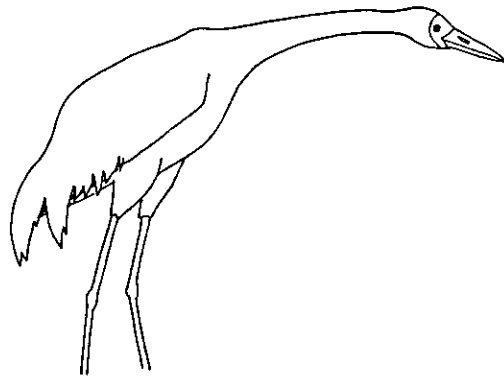
The fourth suggestion is for the scientists concerned to carry out research work on sarus cranes in Xishuangbanna Autonomous Prefecture of Dai Nationality.

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CHAPTER 4  
MIGRATION AREAS





## THE SPRING MIGRATION OF SIBERIAN CRANES AT LINDIAN COUNTY, HEILONGJIANG PROVINCE, CHINA

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### ABSTRACT

This paper reports observations on arrival, departure, and numbers of Siberian cranes *Grus leucogeranus* at Lindian, on the east side of Zhalong Marsh in Heilongjiang Province, China, in spring 1988. Siberian cranes arrived almost daily from 8 April until 8 May, with a peak population of 806 birds from 8-12 May. Violent storms on 29 April and 3 May were accompanied by large increases in cranes. The resting cranes formed three main flocks. Most families consisted of two birds. All cranes departed 13-16 May.

### INTRODUCTION

The reed marsh of Lindian County (ca. 47° 10' N, 124° 26' E), on the east side of Zhalong Marsh, is a part of Zhalong Nature Reserve. This area is an extremely important stopover site during the spring migration of the Siberian crane.

In the spring of 1988, we recorded the spring migration of Siberian cranes during our studies of other cranes, while making prolonged observations from the Huluxin. The Huluxin afford an excellent vantage point, only 1 km from the nearest flock. A lookout tower (about 8 m) had been set out for crane observation.

We used 40 x binoculars for data collection. Whenever Siberian Cranes passed by, arrived or departed, we made daily counts (weather permitting) at 1700 to 1800 hours; we made two or three counts, and the average error was less than 10%. Occasionally, we took five counts for correction. In addition, we kept the Siberian cranes under observation from daybreak to evening.

### RESULTS

In the spring of 1988, the earliest arrival of 10 birds occurred on 8 April at Lindian. From 14 April to mid May, the population of Siberian cranes increased almost every day (see Table 1 and Figure 1). The cranes stayed at Lindian for 40 days; perhaps some of them were passing by. The main flock remained for as long as one month.

The cranes arrived in evening at 1700 hours on 14 April, at 1600 hours on 15 April and at 1736 hours on 16 April. Arrivals did not occur, however, when we observed the whole day before 1600 hours.

The cranes which flew from south to north arrived at the reed marsh of Huluxin, wheeling in the air (2-3 circles). They called and broke up their flock into families of 2-4 birds and non-family groups. In our surveys it was quite clear that 80% of the crane families consisted of two birds (see Table 2). The number of the cranes in spring 1988 reached a peak on 8-12 May, when all 806 birds were present. The number of cranes arriving showed a dependence

on the bad weather. There were violent storms on 29 April and 3 May. After the bad weather, however, the numbers of cranes present had distinctly increased when counted the next day.

Siberian cranes arrived in Lindian and made up three main flocks (see Figure 2). They separated along the edge of a pool, feeding and roosting in thin reed marsh. The position of the flocks persisted almost until they were leaving for the north. The period of departure was short. All the cranes departed from 13-16 May. They flew up about 1000-1200 hours. When the Siberian flock departed, they were wheeling in the air (2-3 circles). The numbers of the flocks were about 12-70 birds (usually 50-60 birds) arranged in the form of "—," and they flew northward into the upper air. On such days, the weather was bright and clear, the temperature was higher, and the wind speed was less than 5 m/sec.

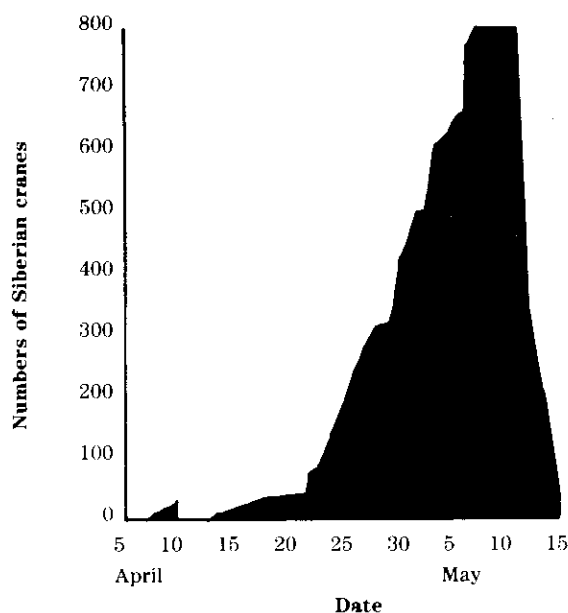


Figure 1. Numbers of Siberian cranes at Lindian.

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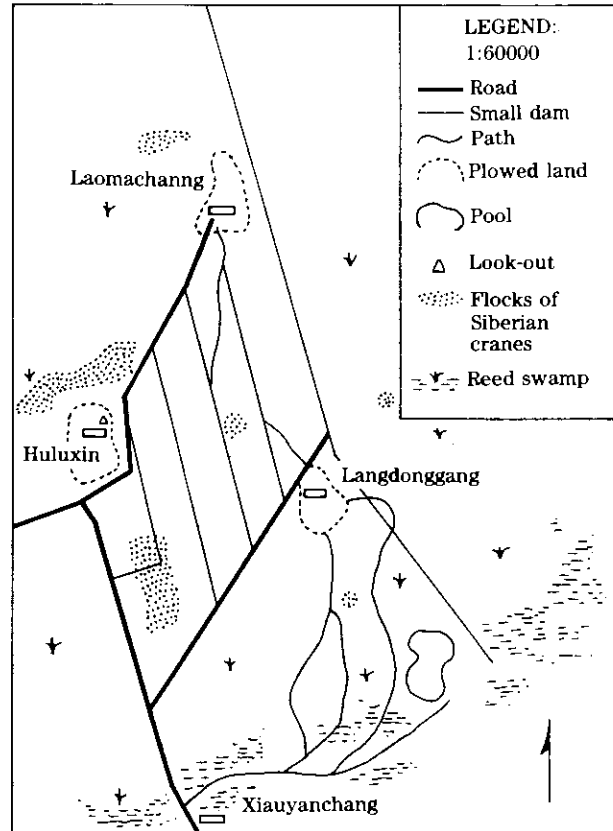
Date	#of cranes	Temp. (av. c°)	Wind direction	Force of wind	Notes
8 Apr.	10	5.15	N	1-2	perhaps birds
9 Apr.	15	6.05	S to N	0-1	before 11 April
10 Apr.	26	8.6	SE to S	3-6	passed north, not
11-13 Apr.	0	1-2	N	5-7	counted in 806 total
14 Apr.	5	7.2			
15 Apr.	18	13.9			
16 Apr.	28				
17 Apr.	28?				strong wind
18 Apr.	38				
19-21 Apr.	38		NE, NW		rain with snow
22-23 Apr.	73				
24 Apr.	133				
25 Apr.	182				
26 Apr.	223				
27 Apr.	269				
28 Apr.	315				
29 Apr.				7	
30 Apr.	421				
1 May	457				
2 May	497				
3 May					strong wind
4 May	613				
5 May	623				
6 May	659				
7 May	776				
8-12 May	806				
13 May	330	17.1 (max 27.7)	WSW	0-3	depart 2 flocks
14 May	213	18.2 (max 22.4)	S to WSW	0-2	depart 3 flocks
15 May	48	17.3 (max. 23.2)	S	3	depart 4 flocks
16 May	0				fine day, all departed

**Table 1.** The numbers of Siberian cranes at Lindian in spring 1988.

## DISCUSSION

According Zhang Semin (pers. comm.), total numbers of wintering Siberian cranes were 1658 at Poyang Lake in 1987-88 winter; the first migratory flock, over 400 birds, left on 9 March; the last migratory flock left on 3 April. Therefore, it is likely there are some other unknown stopover places on the cranes' migrating route. It is necessary for protection of the cranes to discover the stopover places and to do more future studies.

Every year, the numbers of migratory Siberian cranes in Lindian varied: 121 in 1981 and 159 in 1982 (Xu et al. 1985), 217 in 1983, 570 in 1984, 531 in 1985 and 525 in 1986 (Li et al. 1987). These numbers do not mean the Siberian crane population is increasing. Perhaps, some variation was



**Figure 2.** Spring stopover locations for Siberian cranes in Lindian, 1988.

number of individuals observed together	1	2	3	4
number of times observed	25	705	144	5
percent of observations	2.8	80.2	16.4	0.6
total number of observations	879			

**Table 2.** Frequency of Siberian crane observation for families, pairs, and single birds, spring 1988.

caused by survey errors. More importantly, the numbers of migratory Siberian cranes in Lindian is related to local weather. Siberian cranes choose a clear day for departure. Warm weather is good for cranes migrating north.

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## OBSERVATIONS OF MIGRATORY SIBERIAN CRANES AT MOMOGE NATURE RESERVE

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### ABSTRACT

Momoge Nature Reserve, one of the important stopover places for Siberian cranes *Grus leucogeranus*, is located on the lower reaches of the Nen River. From autumn 1983 to spring 1986, we observed the migration duration, stopover habits, and population composition of the Siberian crane at the reserve. The cranes stopped about 40-50 days at Momoge in both spring and autumn. Their habitats were marshlands and wet meadow-grasslands. The total population was about 300-400 birds. The percentages of young in spring and autumn were 17.5% and 24%, respectively.

Momoge Nature Reserve in Jilin is located on the lower reaches of the Nen River, at 45°45' - 46°10' N. and 122°27' - 124°4' E., about 144,000 ha in size. The wetlands cover two-thirds of the reserve. It is one of the most important stopovers for Siberian cranes. The migratory time, numbers, the population composition, and habitats of the cranes have been investigated from autumn 1983 until spring 1986.

### MIGRATION

Most Siberian cranes stop for about 40-50 days at Momoge Nature Reserve in the spring and the autumn; a few cranes only stay a couple days.

In spring, the earliest day when the cranes occurred was 25 March in 1985 and 1986 at the reserve. The number was small at the beginning, only 3-4 birds for each flock. From the end of March until early April, the number increased to 150-200. According to our observations in the springs of 1985 and 1986, the population size was about 100 cranes, staying more than 40 days. Siberian cranes started to depart north from the last ten days of April to early May. In 1985, we found a large flock, about 200 birds, at the end of April. The last flock was seen on 10 May 1985.

In autumn, migratory flocks of Siberian cranes were not so large as in the spring. Cranes first appeared on 14 September in 1983 and 1984, and 29 September in 1985. The normal number in autumn was about 100 birds. Most of them stayed for a long period. At two stopover places in autumn 1985, the birds stayed 28-40 days, totaling 48 and 39 birds at the two sites. The Siberian cranes started to migrate south on the same date in 1983, 1984, and 1985, 7 November.

### DISTRIBUTION AND HABITATS

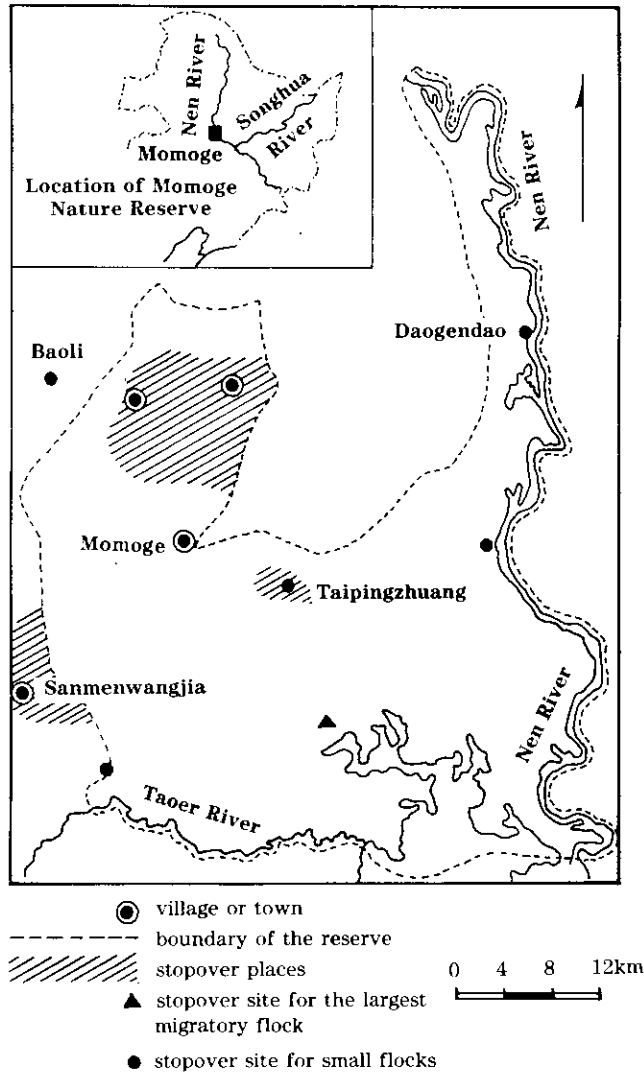
The cranes stopping for a short time were distributed

mainly in the marshlands along the valley of the Nen River. places like Daogendao, Harnao, and Yueliangpao. In migratory seasons, the flocks, about 10-20 cranes, were seen resting for a night or 4-5 days and then leaving.

The cranes staying longer than others were distributed at Gallate-Harlata, Sanmenwangjia, and Taipingsheng in the middle of the reserve. The distance between these places and the Nen River is about 60-70 km. The habitat there is flat wet meadow-grasslands with scattered marshes with water about 30-50 cm deep. The altitude here is from 136 to 140 m. The main vegetation is *Aneurolepidium chinense*. *Artemisia anethifolia* and *Suaeda glauca* are mostly around water. There are reeds *Phragmites communis* in wet places.

Siberian cranes have greatly traditional habits for selecting stopover places. Especially, the flocks that stop for a long time hardly changed their stopover places. Since the autumn of 1983, when we found Siberian cranes at Gallate-Harlata, the cranes have been seen here every migratory season. They even used the same places. So did the cranes at Sanmenwangjia, since autumn in 1984. Figure 1 shows the distribution of Siberian cranes in Momoge.

In fact, at Momoge Nature Reserve, there are many human activities in the cranes' habitats. At Gallate, for example, one of the important stopover places, human activities surround the 2 km<sup>2</sup> wetland. There is a highway to the east, a village to the west, a road to the north, and a railway to the west. People move around the habitat every day. The cranes here were not disturbed because local people were careful not to bother the birds. Every year in spring and autumn, there are about 40-50 birds staying here for about 80-90 days. Some flocks approach within about 50-100 m of the road. Usually, the flocks were found at the same seasons and same places every year. Of course, the tolerance of the cranes for people has a certain limitation. There are so many birds in Momoge Nature Reserve due to the reserve's conservation efforts.



**Figure 1.** The distribution of Siberian cranes in Momoge Nature Reserve.

#### POPULATION COMPOSITION

The total migratory Siberian crane population at Momoge is about 300-400 individuals for each migration season. We can only distinguish chicks, less than one year old, and adults by their outer body characteristics in the field. In September and October, the chicks arriving at Momoge were about three months old (Johnsgard 1983). The body length of young birds is about 110 cm, smaller than that of adults, 137 cm. The chicks' heads, necks, backs, and some feathers of the shoulder and middle tail are yellow brown. Their bills and legs are dark brown, unlike the adults. In March and April, the body size of young birds, about nine months old, was hardly distinguishable from the adults. One still could tell the young birds from adults by their plumage color. Young birds' heads, necks, and backs looked gray from far away. There were scattered brown feathers when one watched from a short distance. Their bills and feet had changed from dark brown to light red.

When, at 15 months age, the young cranes visit Momoge again in autumn, their plumage color is similar to the adults. But their behavior is different from the adults.

In autumn, migratory crane flocks are smaller than in spring. The flocks mostly consisted of families. In autumn 1985 and 1986, we found 24 flocks of Siberian cranes. Only two flocks had more than 20 birds. The largest flock was 28. Three flocks had 10-19 birds. Most of the flocks were 2-9 birds. According to observations in autumn 1985, three-month-old chicks numbered 28 in a total of 134 birds, about 20.9%. In 1986, there were 24 young in 100 birds, or 24%. The percentage of young birds in the Momoge migratory population is higher than at Poyang Lake, about 10.0-14.8% (Chen and Wang, this proceedings). The families usually have two adults with one young in autumn. We only saw two families in which the parents brought two young in 1985 and 1986. Momoge's population is dominated by a family structure of two adults : one young. Of 100 birds in autumn 1986, there were 22 families with 2 adults and 1 young, and 1 family with 2 adults and 2 young. There were 6 pairs of cranes in the migratory population. The other birds were in flocks with 4-6 birds. The individuals of these small flocks foraged and roosted together. They did not mix with other flocks until they migrated south. If the paired birds are adults, and the flocks with 4-6 birds are subadults, the population composition in 1986 was: young, 24 birds, 24%; subadults, 16 birds, 16%; adults, 60 birds, 60%.

In the spring, the migratory flocks are larger than in the autumn. In 1986, we found 20 flocks. Four of them had over 50 birds. The largest flock was 62 birds. There were four flocks with 20-49 birds. There were four flocks with 10-19 birds. The rest, eight flocks, had less than 10 birds. The ratio of the large flocks (over 10 birds) to the small flocks (less than 10 birds) was 12:8 in the spring. The ratio was 5:19 in the autumn.

The flocks with larger numbers stopped for just a short time, and the number of young birds was low. In spring 1985, we found a large flock, 68 cranes, in which there were only 4 young birds at Harlata. The small migratory flocks usually stayed more than 30 days and had a large number of young birds. Among 22 adults, there were six young at Sanmenwangjia in spring 1986. In general, the number of young birds in flocks in spring was smaller than in autumn. There were 22 young birds in 126 cranes according to our counts in spring 1985 and 1986, 17.5% of the total.

#### DISCUSSION

It has been suggested that Siberian cranes migrate up and down the Nen River in the northeast of China (Zheng 1983); finding migratory flocks at Momoge Nature Reserve confirms that suggestion. By recent reports, the migratory route of Siberian cranes in the eastern flocks is: after breeding in eastern Siberia of U.S.S.R., the cranes migrate to the east of China in autumn, then continue along the Nen River and pass through Zhalong Nature Reserve (Lindian) in Heilongjiang Province, Momoge and Xianghai

Nature Reserves in Jilin Province, then pass the mouth of the Liao River in Liaoning Province, then to Shandong Province, and pass by Shengjin Lake at Anqing in Anhui Province, finally to arrive at Poyang Lake in Jiangxi Province for wintering (Li and Feng 1982; Ding, 1986; Liu et al. 1986). Our suggestion is consistent with the terrain and

topography of China.

Momoge Nature Reserve is located midway between the breeding and wintering grounds. Also it has good wetland habitats for cranes. It is not surprising that so many migratory Siberian cranes stopover here. It is important not only to do more study, but also to protect the habitats.

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# MIGRATION OF CRANES AT BEIDAIHE BEACH, HEBEI PROVINCE, CHINA

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## ABSTRACT

This paper is based on the results of bird migration surveys at Beidaihe Beach, Hebei Province, China during spring 1985 and autumn 1986. The surveys were intended to update and expand data from studies of migration at Beidaihe from 1942-1945 and at nearby Qinhuangdao from 1910-1917. The results agree with the previous surveys, indicating that Beidaihe lies on a major crane migration route. Six species of cranes were recorded. Particularly notable totals were 652 Siberian cranes *Grus leucogeranus* during spring 1985, and 529 hooded cranes *G. monacha* and 497 red-crowned cranes *G. japonensis* during autumn 1986. The data from common *G. grus* and Siberian cranes may indicate that these species have declined over the course of this century. Information is presented on passage periods, daily patterns of occurrence, and modes of flight. Correlations between numbers of passing cranes and weather are noted. Predictions are made of possible staging areas. It is recommended that steps be taken to conserve cranes along their migration routes. One such step could be the creation of a reserve as part of the proposed migratory birds' center at Beidaihe. The reserve could act as a staging area.

## INTRODUCTION

Beidaihe (more accurately, Beidaihe Haibin - North Dai River Beach: ca. 39°47' N, 119°27' E) is a seaside resort on the northern part of a plain that occupies much of Hebei Province (see Figure 1). Approximately 15 km inland of the town is the southeastern extent of a mountain range, the southern flank of which extends roughly westward for over 300 km. The eastern flank of the range runs roughly parallel to the coast and bounds a northward extension of the plain: the resultant coastal strip runs approximately northeast to southwest and acts as a "funnel" for many of the birds with migration routes that are believed to cross the area (Tugarinov 1931; Zheng 1976). The resultant high density of migration is, perhaps, enhanced by the small hills at Beidaihe which contrast with the flat land nearby. Especially to the south of the town, the hills probably act as good landmarks for migrating birds.

Studies of migration in the area — by La Touche (1920, 1921) at nearby Qinhuangdao from 1910-1917 and by Axel

Hemmingsen (Hemmingsen 1951; Hemmingsen and Guildal 1968) at Beidaihe from 1942-1945 — together with occasional observations by Wilder and Hubbard between 1894 and 1940 (Wilder 1924, 1940; Wilder and Hubbard 1924) have shown that cranes were among the birds that passed through in large numbers. That cranes have occurred over a considerable period of time is indicated by an inscription on a stone plinth erected in 1919, which alludes to dynasties rising and falling while the wind continues to sing in the forest and cranes are still heard in the mountains.

In spring 1985, the Cambridge Ornithological Expedition to China surveyed bird migration at Beidaihe from 15 March to 1 June. A follow-up survey, China Cranewatch 1986, took place from 20 August to 20 November 1986. The latter expedition was hosted by the Beijing Zoological Society. The surveys were primarily intended to produce data that could be of value in both current and future assessments of population changes. This paper is based on the results of the surveys, full accounts of which are available elsewhere (Williams 1986, 1987b).

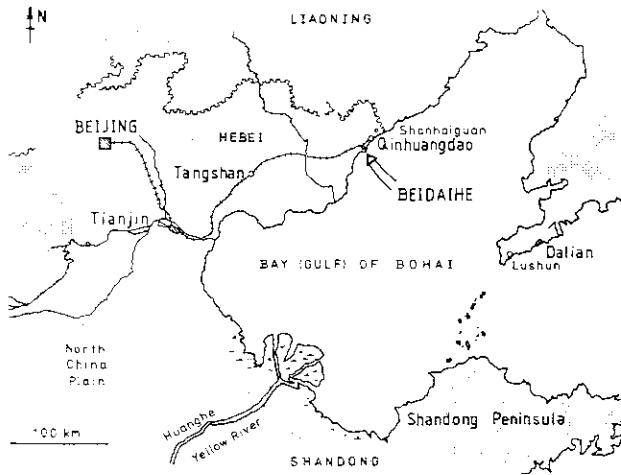


Figure 1. Location of Beidaihe in northeast China.

**METHODS**

Observation using binoculars and telescopes was the means of data collection.

The great majority of the cranes noted during the surveys were recorded during periods of prolonged observation from the Lotus Hills (see Figure 2). These small hills lie on the western edge of Beidaihe and afford an excellent vantage point for recording passing birds. Passing cranes were occasionally noted from other localities. Comparison of flock sizes and times of passage of such birds allowed discrimination of individuals that had been recorded from more than one locality, and hence prevented erroneously high counts being entered in the daily log.

From 16 March to mid April 1985, counts from the Lotus Hills were made daily (weather permitting) and, at minimum, covered the period from 0800-1500. The peak crane migration periods were covered by these counts. Daily counts, typically beginning by 0700 and continuing to 1300 or later, were made from mid April to mid May. Similarly, daily counts were made during autumn 1986,

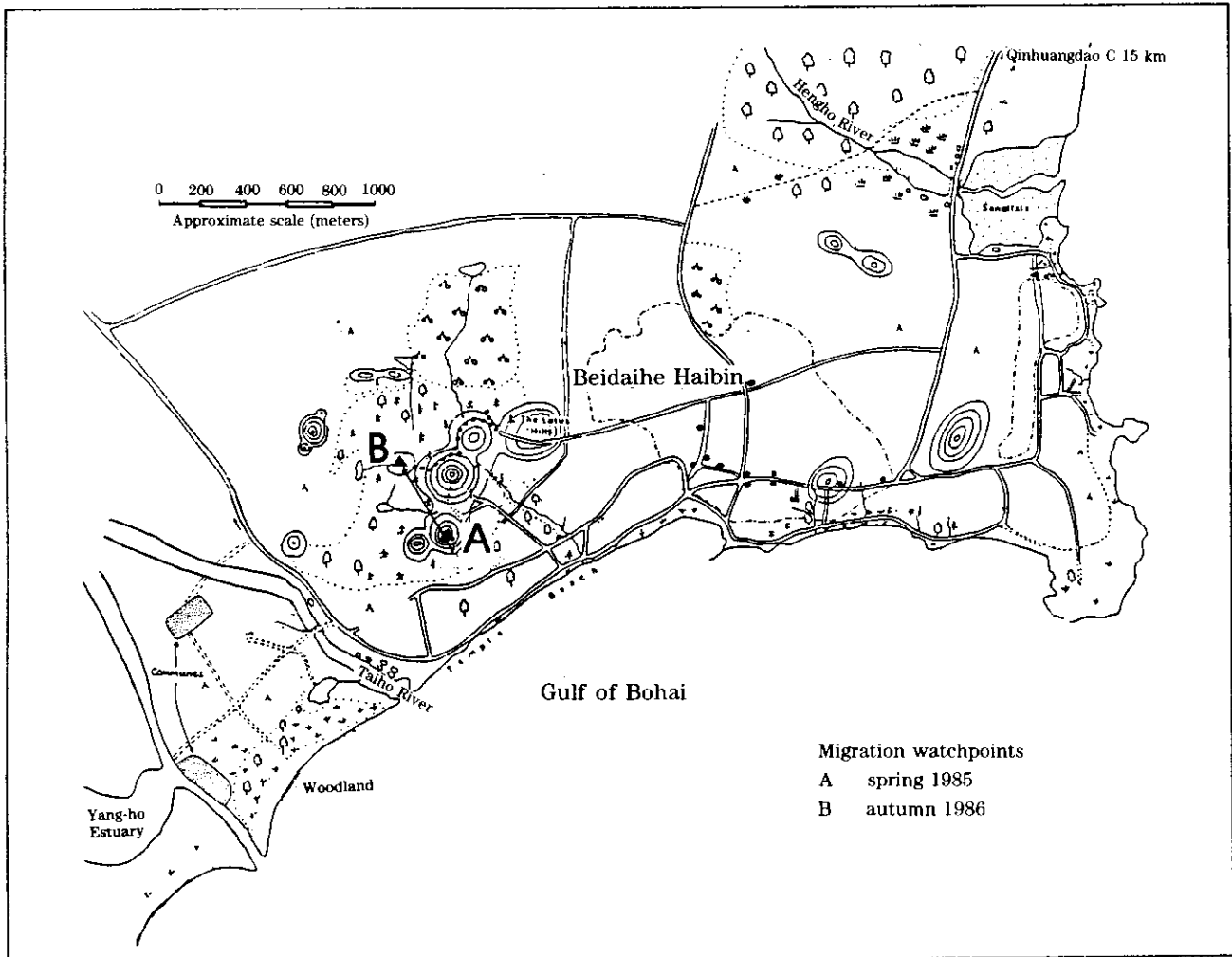


Figure 2. Crane observation points at Beidaihe.

typically beginning by 0700 and ending at 1700 or later. In both seasons, the observations began earlier when the weather seemed promising for migration and were extended when good numbers of birds were passing.

The majority of the birds were located by scanning the horizon with binoculars. In the spring, attention concentrated on the region southwest of Beidaihe; attention in autumn concentrated on the region northeast of the town. These proved the most productive sectors for initial detection of passing cranes.

Counts were rarely made by less than two observers. Four observers were present during all periods of heavy crane migration in spring; five to nine observers were present during such periods in autumn.

Ages of cranes (juvenile, subadult, or adult) were determined whenever possible in autumn. The routes followed by many of the autumn crane flocks, together with places at which they used thermals, were roughly plotted on sketch maps of the area.

#### Factors Affecting Comparability of Studies

At least four factors, excluding changes in the numbers of birds occurring, led to survey results that differed from those of Hemmingsen.

**Number of Observers.** Hemmingsen virtually worked alone (he notes a few records by other observers).

**Optical Equipment.** Hemmingsen first used "not too good field glasses". From June 1943 he used his 8x and 18x binoculars. Each 1985-1986 survey member had binoculars and a telescope.

**Watchpoint Used for Passing Bird Counts.** Hemmingsen made most of his observations in the eastern part of Beidaihe. Particularly in spring, we found that the Lotus Hills provided a far better watchpoint for recording passing cranes.

**Degree of Concentration on Passing Bird Counts.** Hemmingsen studied both grounded and passing migrants; it seems that he paid most attention to recording passing birds when visible migration was in evidence. He appears to have relied heavily on hearing calls in order to detect passing cranes (though to minimize the numbers missed he paid his servant or his servant's children for each flock that they pointed out).

All these factors probably mean the numbers of birds recorded by Hemmingsen are a considerably lower proportion of the total birds passing than are the numbers recorded during the surveys.

#### RESULTS

Six species of cranes were recorded during the surveys. The total numbers of cranes recorded in spring 1985 and autumn 1986 were very similar (7399 and 7412, respectively); this is largely a result of the totals for common cranes, together with unidentified cranes (most of which were probably common cranes), being similar (6194 in spring 1985 and 6040 in autumn 1986). Four of the crane species (red-crowned, hooded, white-naped *Grus vipio* and Siberian) are listed in the ICBP/IUCN Red Data Book (King 1978-1979). Totals of 652 Siberian cranes in spring 1985 and

501 red-crowned and 527 hooded cranes in autumn 1986 are noteworthy. These totals represent over 40% of the known world population of the Siberian crane, and majorities of the known Chinese wintering populations of the latter two species.

The figures given below — other than those for totals of cranes recorded during the whole of the surveys, during peak passage periods, or on days of heavy migration — refer to birds recorded from the Lotus Hills.

The abundance, peak passage periods, and number of aged birds of each of the six species of crane recorded during the surveys are given below. Additionally, information is given on the occurrences of a hybrid crane and of unidentified cranes.

The account for each species opens with a brief resume of the findings of previous authors concerning its abundance or distribution. This generally involves the observations of La Touche and Hemmingsen, augmented where appropriate by those of Wilder and Hubbard. Authors' names are abbreviated as follows: H = Hemmingsen and Guildal (1968); LT = La Touche (1920, 1925-34); and WH = Wilder and Hubbard (1924).

#### Common Crane

LT - immense flocks of cranes, believed to be mainly this species, pass over during March and early April and again in October. H - main spring passage in March; totals of 1028 (1943), 426 (1944), and 2796 (1945). Main autumn passage mid October to early November; totals of 3059 (1942), 4448 (1943), 4228 (1944), and 8404 (1945).

**Spring 1985.** A total of 4409 passed north from 15 March to 7 May. The majority (4321) passed from 21 March to 5 April, with the highest day's total being 1424 on 31 March.

**Autumn 1986.** We recorded 4483 birds from 7 October to 18 November. Additionally, five flocks were heard passing after sunset: one on 29 October and four on 5 November. The main passage occurred from 25 October to 10 November, with 3690 birds recorded. The peak day count was 1263 on 5 November; other notable totals were 412 on 29 October, 680 on 1 November and 485 on 6 November.

We aged 871 birds, of which 733 (82%) were adults, 3 (0.3%) were subadults and 135 (15.5%) were juveniles.

See our records below under "unidentified cranes."

#### Red-crowned Crane

LT - only heard of two captured in seven years; other flocks probably refer to the Siberian crane, as some had black primaries. H - noted in spring from 12-25 March, with a total of 90 recorded (additionally, 125 probable red-crowned cranes were seen by another observer). Autumn records from 22 October to 23 November, with totals of 6 (1942), 151 (1943), 92 (1944), and 98 (1945).

**Spring 1985.** A total of 244 was recorded from 15-31 March; 50 on 22 March and 21 on 23 March were notable day totals. Since the species is an early migrant (Hemmingsen and Guildal 1968) it is possible that a number passed prior to the commencement of the survey.

**Autumn 1986.** We recorded 501 birds from 13 October to 19 November. The main passage occurred during November: 423 birds passed from 5 November to the end of the survey. The maximum day count was 180 on 7 November; 61 on 14 November was another notable day total.

We aged 206 birds, of which 158 (76.7%) were adults, 45 (21.8%) were juveniles, and 3 were subadults.

#### Hooded Crane

LT - no records. WH - 3 on 21 April 1923 and from 20 to several hundreds flying south 8-9 October 1923. Both records are of "white-necked cranes" and may refer to the hooded crane. Rather confusingly, a migration note by Wilder (1924) only mentions one flock of white-necked cranes seen over 8-9 October. H - 10, plus 50-100 probable, in 1943 were the only spring records. Autumn records from 12 October to 7 November; at least 140 recorded in three seasons.

**Spring 1985.** The hooded was the latest of the cranes to migrate, with 309 birds recorded from 25 March to 20 April. On 2 April, 257 flew north.

**Autumn 1986.** We recorded 527 birds flying south from 11 October to 7 November. The first record, of a single bird, was not followed until 29 October. The main passage occurred over 5-7 November: 446 were recorded during this period, of which 436 passed on 5 November.

We aged 309 birds, of which 257 (83.2%) were adults and 52 (16.8%) were juveniles.

It is interesting to note that, in both seasons, the great majority of the birds passed in just one day.

#### White-naped Crane

LT - no records. WH - see above, under "Hooded Crane." H - three records, involving a total of 46 individuals believed to be this species, in late October and early November.

**Spring 1985.** No records.

**Autumn 1986.** We recorded 152 birds flying south from 17 September to 6 November. The main passage occurred from 25-29 October; 92 birds passed during this period.

We aged 25 birds, of which 21 (84%) were adults and 4 (16%) were juveniles.

#### Siberian Crane

LT - great numbers March, April, October, and November. WH - large flocks of from 50 to 300 were flying north on 6 April 1916. Despite later doubt (Wilder 1924) these were surely Siberian cranes (Wilder described them as "great white birds with black tipped wings and necks straight out in characteristic crane fashion . . . too high in the haze for certain identification." The description does not fit the red-crowned crane, which has mainly white wings, and it seems very unlikely that Wilder would have mistaken flocks of storks, which do not fly in V-formation or soar in a coordinated manner, for flocks of cranes). Approximately 140 passed south on 6 October 1923. H - possible on 17 March 1943, none in spring 1944 and 628-728 in spring 1945.

Autumn totals of 15 (1942), 227 (1943), 80 (1944), and 34 (1945).

**Spring 1985.** We recorded 652 birds passing north between 20 March and 1 April, with all except 12 passing over 20-26 March. The largest flock numbered 108 birds.

**Autumn 1986.** We recorded 192 birds passing south between 11 October and 10 November. Passage, though somewhat sporadic, mainly occurred from 29 October to 10 November; 99 birds were recorded during this period.

We aged 155 birds, of which 121 (78%) were adults and 34 (22%) were juveniles.

#### Demoiselle Crane

LT, WH, H - no records.

**Spring 1985.** No records.

**Autumn 1986.** We recorded 14 birds flying south as follows: one on 7 November, 12 on 14 November, and 1 on 15 November.

Three birds were aged, of which two were adults and one was a juvenile.

#### Unidentified Cranes

**Spring 1985.** We recorded 1785 unidentified cranes from 22 March to 2 April; two late birds passed north on 20 April. It is probable that the overwhelming majority of these birds were common cranes (in addition to being the most abundant of the cranes, the common crane appears featureless at a distance).

**Autumn 1986.** We recorded 1557 unidentified cranes. Of these, 7 were probably common or demoiselle, 260 were common or white-naped, and 478 were common or hooded (the latter passed on 5 November, when both common and hooded cranes were passing in numbers).

#### Daily Pattern of Occurrence

The daily pattern of occurrence of each of the crane species recorded in spring was bimodal - there was a minor peak early in the day and the main passage occurred in the early afternoon (see Williams 1986).

Alerstam and Bauer (1973) found a similar distribution for the migrations of common cranes over southern Scandinavia.

In spring, the common cranes, particularly, passed mainly from 1200-1500 (over 65% of the common cranes passed during this period). Similarly, Hemmingsen (1951) found that the cranes tended to pass from 1100-1600; 87% of the cranes he recorded in spring passed during this period.

The autumn data do not display such clear bimodal patterns as the spring data. Passage again occurred mainly during the afternoon, though it was less concentrated than in spring. We recorded 2759 common cranes (58% of the total) during the period 1300-1600. Six flocks were heard passing after dusk; we did not hear cranes after dusk in spring. Similarly, Hemmingsen (1951) also heard cranes passing at night in autumn (21 times) but not in spring.

In autumn, the red-crowned crane tended to occur later in the day than did the other species: 358 (71.7% of the total recorded) passed during the period 1500-1700.



## Routes

The cranes tended to fly parallel to the coast (i.e., they flew roughly northeastward in spring and southwestward in autumn).

In spring, at least 70% followed the corridor bounded by the coastline and the mountain flanks: hence, many passed to the west of the Lotus Hills and relatively few overflowed the town. On several occasions crane flocks were observed passing at distances which precluded any plumage features being discerned, even with the use of telescopes (these flocks were probably over 6 km from the Lotus Hills).

The situation was reversed in autumn, when most birds passed to the east of the hills (of 4779 for which route maps were plotted, 3091 passed to the east of the Lotus Hills and only 101 flew inland at distances estimated at 6 km or more).

## Effects of Weather

The numbers of cranes passing showed a strong dependence on the weather. As noted by Hemmingsen, the birds tended to occur on certain days in waves, with few cranes appearing on intervening days.

In the spring, the largest numbers of cranes were recorded on days when the pressure fell as high pressure systems moved away to the east of Beidaihe. These waves were very pronounced - over 5000 of the 7399 cranes passed on just four dates (21, 22, 26, and 31 March) (see also Williams 1986). Hemmingsen's data show a similar relationship between waves of crane migration and air pressure.

Other studies of migration in the northern hemisphere (e.g., Nisbet and Drury 1968; Williamson 1968; Blokpoel and Richardson 1978; Mao 1985) have also shown that spring migration preferentially takes place on the western flanks of high pressure cells. The conditions thus selected for migration, typically involving clear weather and warm winds with a southerly component, allow the birds to migrate with minimum effort and heat loss and are ideal for navigation. Additionally, these conditions are those which best predict high clouds (and/or lack of rain) and high temperatures at the destination (Nisbet and Drury 1968). Hence, the birds minimize the energy loss during migration and optimize their chance of survival at the destination, where food may be scarce (Blokpoel and Richardson 1978).

Fine weather and winds having a southerly component have been found to stimulate the spring migrations of common cranes (Alerstam and Bauer 1973; Swanberg in press; Alonso et al. in prep.), and sandhill cranes *Grus canadensis* (Nesbitt 1975). Whooping crane *G. americana* migration is highly dependent upon favorable winds (M. Howe in litt.). These conditions prevailed on days when large waves of crane migration were recorded during the spring survey.

A wave of hooded crane migration on 2 April (257 birds, 83% of the total recorded) appears anomalous since a low pressure system had just moved eastward over the area. No other cranes were seen on this date. It may be that this wave partly reflects a lack of dependence by this species

upon thermals for migratory flight (the day was overcast and misty, hence thermal development would have been minimal).

Waves of migration were again evident in autumn, when 4637 of the total of 7412 cranes were recorded on four dates (29 October, 1, 5, and 6 November). In contrast to the spring, these waves were associated with the arrival of high pressure cells (i.e., the cells lay to the west of the town). This accords with the findings of other studies of autumn migration (Elkins 1983).

It is interesting to note that while 562 cranes were recorded on 29 October, when a high pressure cell approached and moved over the town, none were observed on 30 October, when the cell moved away to the east of the town. The synoptic chart for the latter date is very similar to those charts for spring wave days. The lack of cranes may well indicate that the birds strongly prefer to migrate with winds favoring the migration direction (the conditions would otherwise appear very suitable for migration).

## Flock Formation and Occurrence in Family Parties

All species of crane were seen passing in flocks. These flocks were as described by Hemmingsen (Hemmingsen 1951; Hemmingsen and Guildal 1968): when not using thermals, the cranes flew in V-formations that nevertheless showed a large amount of variation. The tendency to form flocks appeared greatest in common, hooded, white-naped and Siberian cranes. As one might expect, the flock sizes seemed largely to depend on the numbers of birds passing - flocks tended to be larger on wave days. The largest flock recorded in spring numbered 330 common cranes; in autumn, 261 common and hooded cranes formed the largest flock.

Red-crowned cranes showed less tendency to form large flocks: the largest flock in spring numbered 45 birds, and in autumn 27 birds. Hemmingsen (1951) also found this species to be less gregarious than the other cranes. He noted that the species tended to occur in numbers of four birds or less. We found that this was not the case in spring, when only 1 of the 14 observations of the red-crowned crane was of four birds or less (Hemmingsen only saw six parties of the species in spring, two of which numbered four birds or less). Our autumn observations, however, agree with those of Hemmingsen; 34 of 68 observations were of four birds or less (only one of these was of a single bird). The ratio is very similar to that reported by Hemmingsen and Guildal (1968); 15 of a total of 33 observations were of 1-6 birds. When the cranes passed sufficiently close, we were able to discern that the "parties" of two birds were adults, those of three birds were two adults with one immature bird, and those of four birds were two adults with two immature birds. Hence, these parties almost certainly represented family units.

The Siberian cranes and the white-naped cranes also showed a tendency to pass in autumn in parties of two to four birds (10 out of 24, and 7 out of 19 observations, respectively). Family groups passed less frequently for the common crane (44 of 138 observations) and the hooded crane (5 of 36 observations). It was noticeable that when

flocks passing in autumn soared in thermals, there was a tendency for birds to separate into family units.

#### Modes of Flight

The cranes tended to progress by flapping flight. They also utilized thermals, which allowed them to gain height and then glide in the migration direction, with occasional flapping flight, until persistent flapping flight or the use of other thermals was required to maintain or regain height. This mode of flight has been described by Pennycuick et al. (1979), who found the birds made greatest use of thermals when thermals were strong. Migrating sandhill cranes fly in a similar manner (Melvin and Temple 1981). It appears that the birds use soaring and gliding flight in order to save energy (Pennycuick et al. 1979).

Red-crowned cranes made least use of thermals. When they did use them, they appeared inept and flapped rather frequently (by contrast, common and Siberian cranes spiralled upward with little apparent effort). Particularly in the spring, it appeared that hooded cranes were also less inclined to use thermals than common and Siberian cranes.

Cranes were never recorded passing at, or attaining, such heights as to make them difficult to locate with binoculars. Indeed, most birds that flew overhead were readily visible to the naked eye.

#### Flight Speeds

At 1225 on 20 April 1985, a flock of eight common cranes was observed passing the Lotus Hills. Only 28 min later a flock of eight was recorded passing Shanhaiguan, about 30 km to the north of Beidaihe. Cranes were so scarce by this date that it seems certain that these records refer to the same flock. If so, the ground speed of the flock was about 64 km/h. The wind was southerly, force two to five; hence, the air speed would have been rather lower than the ground speed. The weather was typical of that recorded on wave days: thus, it may not be unreasonable to assume that the cranes passing on wave days flew at speeds in the range 55-70 km/h.

On 1 November 1986, flocks of 9 Siberian cranes, 20 common and 2 Siberian cranes, and 1 hooded and 12 common cranes were recorded passing the Lotus Hills at 1205, 1245, and 1425. What were presumably the same flocks were later recorded passing over Dapuhe, about 24 km south of Beidaihe, at 1245, 1325, and 1500. The distance and times suggest that the ground speed of the flocks was about 36 km/h. The wind was southwesterly, force four; hence, the air speed would have been higher than the ground speed.

These values are in agreement with studies of the migrations of common cranes (typical ground speeds lay in the range 40-66 km/h: Alerstam 1975) and of sandhill cranes (average daily ground speeds have been found to lie in the range 20-83 km/h: Melvin and Temple 1981).

## DISCUSSION

#### Changes in Abundance Since Previous Work

In using the data to assess changes in abundance since

the time of Hemmingsen, we must take into account the changes in routes followed by birds in spring 1985 and autumn 1986.

The more westerly bias of the migration in spring probably caused observers at the Lotus Hills to be more likely to detect cranes than observers at the eastern part of the town (where Hemmingsen mostly worked). In autumn, most birds flew to the east of the Lotus Hills; observers at the eastern part of the town would have had far more chance of detecting birds during this season. If this seasonal difference is consistent, it seems likely that it accounts in large part for Hemmingsen's autumn counts of cranes in general substantially exceeding his crane counts in spring.

The data for the common crane suggest that the species has declined since 1945, as the spring survey total is not much greater than Hemmingsen's maximum spring total, and the autumn total is substantially less than his maximum autumn total (as noted above, we would expect to record a significantly higher proportion of the passing birds than did Hemmingsen).

The data for the Siberian crane suggest a substantial decline over the course of this century. The records of La Touche (1920) and Wilder and Hubbard (1924), which surely refer to this species, suggest that many more birds occurred during 1910-1917 than were recorded by Hemmingsen or during the surveys. A further, less marked, decline may well have occurred since the time of Hemmingsen.

Too little data is available for comparisons of the abundance of other species.

#### Inter-seasonal Differences in Abundance

The most marked inter-seasonal difference is evident for the white-naped crane, which was not recorded in spring yet occurred in fair numbers in autumn. This may well reflect a change in flyway of the birds between spring and autumn.

A flyway change is also suggested by the data for the Siberian crane. It appears that fewer birds follow the flyway past Beidaihe in autumn than in spring.

#### Tendency to Pass in Family Parties

The tendency for the red-crowned crane, particularly, to pass in family groups presumably indicates that relatively few birds gather at traditional staging areas prior to commencement of autumn migration (autumn staging areas allow birds to congregate into flocks: Melvin and Temple 1981).

#### Daily Pattern of Occurrence and Flight Speeds

Cranes tend to begin migratory flights in mid morning, particularly around 1000-1100 (Alerstam and Bauer 1973; Melvin and Temple 1981; Karlsson and Swanberg 1984; Alonso et al. in prep.). The spread of times for departures of birds are similar to those of cranes passing Beidaihe in spring from 1200-1600 (Williams 1986). Hence, it is possible that many of the cranes recorded during the spring survey originated from a relatively small area. If one assumes that the cranes begin to migrate in numbers

around 1000, it would seem that this area lies some 2 - 2.5 h flight time to the south of Beidaihe.

Assuming a ground speed of 55-70 km/h, the stopover may be estimated to lie some 110-175 km to the south of Beidaihe, on the Hebei plain perhaps somewhere to the east of Tangshan. A description of the area (Wilder and Hubbard 1924) suggests that there are likely to be suitable localities for stopovers. Cranes tend to select stopover sites with shallow water and gently sloping shorelines that are free from disturbance (Melvin and Temple 1981).

The narrow coastal plain to the north of Beidaihe appears to offer few suitable sites for stopovers until it merges with a large plain at the northward extent of the Bay of Bohai, about 230 km to the north of Beidaihe. If our estimate of ground speeds is correct, the birds would take three to four hours to reach this locality after passing Beidaihe. The arrival times for the majority of birds would thus lie in the range of 1500-1900 and the main arrival would take place over 1630-1730. These times are in good agreement with the times of arrival of common cranes at Lake Hornborga, a major crane staging area in Sweden, on spring days with favorable weather for migration (Karlsson and Swanberg 1984).

The less concentrated pattern of occurrence in autumn may well reflect the use of a large number of stopovers to the north of Beidaihe. It is possible that at least some of the birds that pass Beidaihe toward dusk continue only a little way before finding a roost site: cranes formerly roosted at Beidaihe, at an area now covered with trees and hence no longer suitable for the birds, (Hemmingsen 1951; Hemmingsen and Guildal 1968); fishermen at Dapuhe have reported seeing cranes in the fields in recent years. The occurrence of cranes passing at night may well indicate that the birds are heading for a pre-determined locality (Melvin and Temple 1981) and seems likely to reflect a paucity of suitable stopover sites on the coastal plain north of the town.

#### CONCLUDING REMARKS AND SUGGESTIONS FOR FURTHER WORK

Beidaihe evidently lies on a major flyway which is used by considerable numbers of cranes in both spring and autumn. These include significant numbers of red-crowned, hooded, and Siberian cranes, all of which are listed in the ICBP/IUCN Red Data Book (King 1978-1979). Migration studies at the town can yield information on populations, population dynamics, inter-seasonal differences in the migrations, breeding success, and migratory behavior.

The following projects seem worthwhile as follow-up work.

*Continue with counts of cranes passing Beidaihe in spring and autumn.*

Preferably, more than one watchpoint should be used. In spring, a watchpoint to the west of Beidaihe could be tried; autumn counts could be made from the eastern part

of the town (in both cases, these would be simultaneous with counts from the Lotus Hills).

*Locate stopover areas.*

Though Melvin and Temple (1981) found that non-traditional stopover areas were selected rather randomly, the results of the surveys, particularly in spring, suggest that the cranes are rather specific in their selection of stopovers in southern Hebei and in Liaoning.

*Discover more about the cranes' migration path.*

Little is known about the routes followed by cranes between Beidaihe and wintering areas, breeding areas, and traditional stopover areas. Radiotelemetry techniques and appeals to the public for sightings could greatly assist with this effort.

*Locate and survey localities which lie on other flyways.*

White-naped cranes, which occur in numbers at Lake Poyang and breed in northeastern China and the adjacent U.S.S.R., are rare in spring and uncommon in autumn at Beidaihe. Hence, there must be at least one other flyway linking these areas. The surveys suggest that Siberian cranes may also follow another flyway in some numbers, particularly in autumn. Wilder (1934) mentions a line of crane migration from Mongolia down the Yellow River Valley between Shansi and Shensi or further west; Sowerby (1934) notes that the cranes pass down the Fen-ho in Shansi and from the Ordos Desert southward to the Sian Fu plain. Neither author indicates that observations of birds following this route have been other than casual; work of a systematic nature could well be of interest.

*As information becomes known, implement measures to protect migrating cranes.*

Currently, crane reserves in China are largely aimed at protecting breeding and wintering birds. A series of reserves along the flyways could well be of value to migrating cranes.

It has been proposed that a reserve be established at Beidaihe (Williams 1987a). This reserve would include suitable habitat for use as a stopover by cranes. The reserve would benefit the birds both directly (they would be protected from disturbance) and indirectly (they would be observed by visitors to the reserve, thus assisting with conservation education).

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## CRANES IN SHANDONG PROVINCE

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### ABSTRACT

This paper reports on the nature of residence in the province, the time of arrival and departure, and the distribution and numbers of the five species of cranes that have been found in Shandong Province: common crane *Grus grus*, hooded crane *G. monacha*, red-crowned crane *G. japonensis*, white-naped crane *G. vipio*, and Siberian crane *G. leucogeranus*.

Shandong Province is situated in the eastern part of China. It lies in the temperate zone and has a variety of natural areas. The eastern part of the province is a peninsula surrounded by the Bo Sea and the Yellow Sea, facing Liaodong Peninsula and the Korea Peninsula to the north across the sea. The western part of the province lies at the lower reaches of the Yellow River and includes some large lakes and reservoirs. The weather in Shandong is moderate in the coastal area since the weather is affected by the ocean. The lakes, rivers, streams, reservoirs and sea beaches are rich in natural foods, and there is lush wild grasses and shrubs. So, the area is a stopover for many cranes during their migration, and the wintering ground for others.

There are few accounts of research on cranes in Shandong. There is a record of a "common crane dwelling in Rizhao County" in the Annals of Rizhao County of Shandong Province written in the Qing Dynasty (Yang 1710). Concise descriptions of cranes in Shandong were made in the reports on birds in Shandong by Herklots (1935), Shaw (1938a and 1938b), LeFever (1962), Ji (1985), and others. A general survey of birds in the province was conducted from 1983 through 1986 cooperatively by the Department of Biology of Shandong University and the Forestry Bureau of Shandong Province. With the help of the survey groups, we have made an investigation on the cranes in Shandong. The investigation was made at different times in the areas of Qingdao City, Chang Island, Yantai, Rongcheng, Weihai, Jimo, Huimin, Wudi, Chengkou, Weifang, Shouguang, Changyi, Anqiu, Linyi, Cangshan, Zou, Rizhao, Heze, Shan, Wenshang, Weishan, Fei, Pingyi, Taian, Dongping Counties, etc.

### METHODS OF INVESTIGATION

In areas of the province where the cranes are frequently seen during migration, survey groups were organized to observe the cranes at fixed positions using telescopes. The species and time of arrival and departure were recorded, and the numbers counted.

### RESULTS

Five species of cranes — common, red-crowned, white-naped, hooded, and Siberian cranes — were recorded in the province at 25 observation posts from 1983 through 1986. The nature of residence in the province, times of arrival and departure, and numbers of various species in Shandong are summarized in Table 1. According to observations at the 25 survey posts, five species of cranes totalling 113 birds were observed migrating through Shandong, from September 1984 to May 1985. They included 86 common cranes, 14 red-crowned cranes, 6 white-naped cranes, 4 hooded cranes, and 3 Siberian cranes.

Of these, common cranes were the largest in number, distributed widely, and could be seen at lakes, reservoirs, stream outlets, seashores and shoals in the province. The majority of common cranes migrated through the province, but some remained all winter in Rongcheng County. Rongcheng faces the sea on three sides, and its bays, shoals, and lakes provide very good sites for cranes. Eleven common cranes lived through the winter from mid November 1984 to early May 1985. In the last ten days of January 1985, four common cranes were observed on the coastline of Jimo County.

The majority of the red-crowned cranes in Shandong were passing through and a few lived through winter on the seabeaches of Rizhao County. Four red-crowned cranes were observed on the beaches of Rizhao from the end of December 1984 to 1 February 1985. Hooded cranes, white-naped cranes, and Siberian cranes were all passing through Shandong, and the numbers were very small. Figure 1 shows the distribution of the five species of cranes.

### DISCUSSION

Shandong Province is a stopover for five species of cranes during migration and for two species of cranes during winter. Therefore, protecting the cranes and their habitats

in the province is immediately related to the protection of cranes all over China and throughout the world.

We suggest that the departments concerned enhance the protection of the areas at Rongcheng and Jimo, and the

seashores of Rizhao where some cranes live through the winter. We also suggest that appropriate food be set out in some areas for the cranes to help them live through the winter safely and possibly to attract more cranes.

Species	Resident Type <sup>a</sup>	Arrival/Departure	Number	Distribution (counties)
Common crane	m	early March to late May	21	Weifang, Xiashan Reservoir, Wudi, Changshan, Dan, Qingdao, Lichun, Kenli, Taian, Yantai, Dongping, Weishan, Penglai, Weihai
		early Sep. to late Nov.	50	
	w	mid Nov. to early May	15	Rongcheng, Jimo coast
Red-crowned crane	m	early Feb. to March late Oct. to early Dec.		Shouguang, Changyi, Weifang Xiashan Reservoir, Chang Island, Shou Island, Pingyi, Wenshang, Fei
	w	early Dec. to early Feb.	4	Rizhao coast
White-naped crane	m	March	2	Changshan, Zou
		Nov.	4	
Hooded crane	m	late March to early April	1	Wuli
		mid Oct. to late Oct.	3	
Siberian crane	m	late Oct. to Nov.	3	Qingdao

Table 1. Records of cranes in Shandong Province.

<sup>a</sup>m migrant; w winter resident

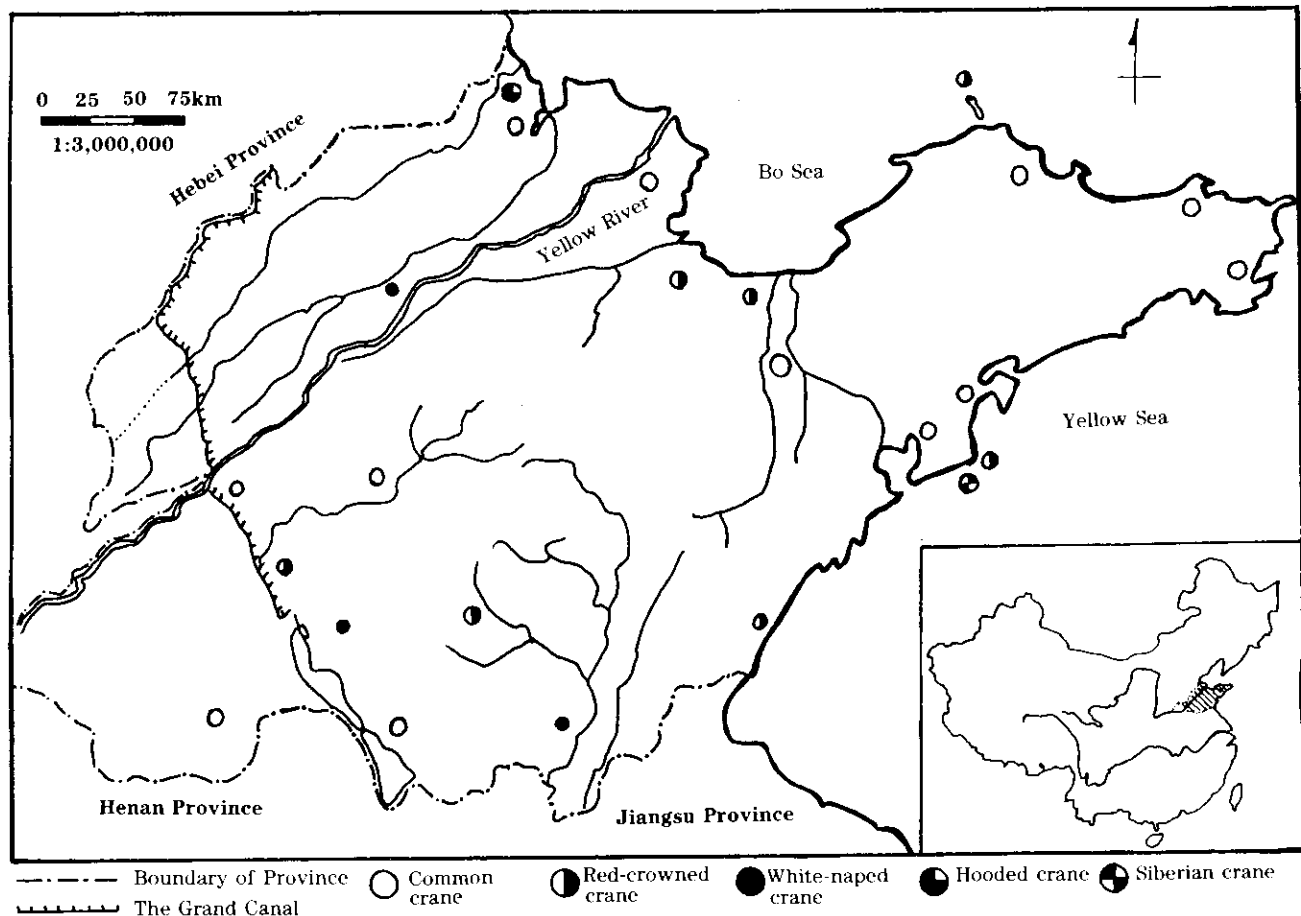


Figure 1. Distribution of five species of cranes in Shandong Province.



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# CRANES IN THE PLACE WHERE THE YELLOW RIVER FLOWED LONG AGO IN HENAN PROVINCE

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## ABSTRACT

Six species of cranes have been seen between October and April in the areas along the abandoned Yellow River channel in Henan. We observed their species, numbers, arrival time and behavior from 1985 to 1987. This information offers a new basis for further studying crane migration routes and habitats in order to protect these birds.

## INTRODUCTION

The abandoned Yellow River channel (the section under investigation) is 35 km northeast of Xinxang City, Henan Province. It is at 35°26' N and 114° 22' E. According to historic records, we know the Yellow River changed its channel more than 1,500 times. Many highlands and lowlands formed with dense grass and a lot of fish—a good place for water birds. There are wetlands dominated by reed *Phragmites communis*, and rushes *Typha latifolia*. There are also young trees planted by the local people: willows *Salix matsudana*, poplars *Populus simoni*, and acaias *Robinia pseudoacacia*.

At the abandoned Yellow River channel area, nearly 40 species of large and medium water birds come to winter or stopover during migration. Eight species are classified as first-class protected animals on the national level.

## NUMBERS AND SPECIES OF CRANES OBSERVED

Table 1 shows species, numbers, and duration of stay for cranes that winter or stopover in the area along the abandoned Yellow River channel. The number of the

common cranes is the largest and that of the hooded cranes is the smallest. In fall, the first migrating cranes are Siberian cranes and the last are red-crowned cranes. In spring, the order is opposite.

## HABITS

Common cranes and demoiselle cranes stay at the abandoned Yellow River channel through winter. You can see them from October to the following April. We found 91 wintering common cranes and 5 wintering demoiselle (one flock) in winter 1985-86. Other crane species stay here only for a short period to rest and feed on their way to the south or the north. Swallows migrate at the same time as cranes. The cranes' migration is closely related to changing of temperature. At the end of autumn, when it is at 0° C, they appear in this area. In springtime, when it is between 0° C and 10° C, they pass through here on their way to the north. Wild geese and ducks usually arrive first, and then the cranes. Unlike common and demoiselle cranes, the length of stay for the other four crane species in this area ranges from one day

Species	Fall Migration			Spring Migration		
	Total Number	Date First Seen	Date Last Seen	Total Number	Date First Seen	Date Last Seen
Red-crowned crane <i>Grus japonensis</i>	12	24 Oct.	8 Nov.	6	5 Mar.	9 Apr.
Hooded crane <i>Grus monacha</i>	11	17 Oct.	4 Nov.	7	9 Mar.	23 Mar.
Siberian crane <i>Grus leucogeranus</i>	33	2 Oct.	26 Oct.	21	24 Mar.	27 Apr.
White-naped crane <i>Grus vipio</i>	14	12 Oct.	29 Oct.	9	10 Mar.	27 Mar.
Common crane <i>Grus grus</i>	139 <sup>a</sup>	5 Oct.	-	107 <sup>a</sup>	-	30 Mar.
Demoiselle crane <i>Anthropoides virgo</i>	15 <sup>a</sup>	11 Oct.	-	8 <sup>a</sup>	-	2 Apr.

**Table 1.** Species, number and duration of stay for cranes on the abandoned Yellow River channel 1985-1987.

<sup>a</sup>for common and demoiselle cranes, the numbers of cranes are for the first flock sighted in autumn and the last flock in spring.

to two weeks. The duration chiefly depends on whether people disturb them.

Wintering cranes stay in the area along the abandoned Yellow River channel in flocks. We found that no crane moved around alone. Siberian and white-naped cranes always use the same areas, but the flocks never mix. Hooded cranes and white-naped cranes often have mixed flocks. The red-crowned cranes are always in small groups of two to seven. Common cranes never mix with other crane species; similarly demoiselle cranes keep separate from other species. Sometimes even different groups of the same species don't mix, perhaps because they come from different places or at different times. In winter, cranes of the same species seldom fight for food. But, there is competition among different species. For example, we have seen white-naped cranes chase red-crowned cranes when flocks of the two species were feeding close together. Such fighting usually happened in shallow water. We have also seen demoiselle cranes chasing common cranes.

There are several advantages for cranes to live in flocks in winter, such as discovering danger in time, enhancing their ability for self-defence, and increasing time of feeding since the time spent on guard is reduced. The latter is very important for them in winter when food is scarce, a critical factor for the survival of a crane population.

The cranes live on seeds of water plants, roots and stalks of grass, wheat seedlings, and corn, peanuts and sorghum left in the fields. In shallow water or swamps, they also eat small fish of many species, shrimp *Macrobranchium* and other small animals in water. Our observations indicate that numbers of water birds increase when areas of water, i.e., amount of precipitation, is larger.

We sighted the flock of five demoiselle cranes six times. They fed in shallow water, sand hills, and farmland. They moved to avoid people, being warier than other cranes, but sometimes they mixed with sheep when feeding.

Vigilance of cranes is high. For a crane flock, there are always some birds (at least one) on guard. The cranes will be alerted even when people are 150 m away. If there is

any unusual situation, they begin to warn their fellows by calling loudly.

#### HUMAN ACTIVITIES

In recent years, there have been more and more human activities along the abandoned Yellow River channel. Therefore, the cranes cannot look for food freely. They are forced to go to the sand hills by the river channel or to low-lying farm land where disturbance is infrequent. They come back to the swamps at dusk to catch small fish or drink water. After dark, they roost quietly near the river. The cranes begin to look for food at dawn. Except when resting, they spend all day looking for food so as to obtain energy for migration.

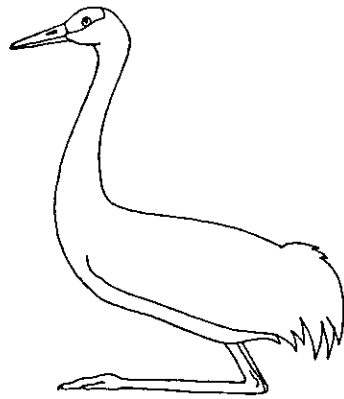
According to local people, some years ago there were many cranes. They weren't afraid of humans even when people were very close. You could hit them by throwing blocks of soil. Now, the cranes are all afraid of people. When disturbed, some red-crowned and Siberian cranes will move away, keep on migrating, or look for safe places to rest.

Various unfavorable factors affect the survival of cranes and other rare birds. At present, people fish in the water and deepen the fish ponds, causing the area of water to decrease gradually. Large areas of shallow water marshes thus become waste land and have been reclaimed for farming. In order to protect their fish, the fishermen kill the cranes and other water birds. In recent years, many people catch fish and cut grass. Always hunters are around. On 26 December 1985, we counted an average 2.3 persons per km. We heard a gun shot every 12 min. If this situation continues, the result is very clear.

This wetland is a stopover for cranes and other migratory water birds. We ought quickly to make effective measures of protection.

We can imagine that if the environment were little disturbed and reeds and rushes left uncut — so that cranes would have places to hide and abundant resources — there would be more and more water birds wintering here.

CHAPTER 5  
CAPTIVE CRANES AND LABORATORY STUDIES





# CAPTIVE BREEDING OF CRANES AT BEIJING ZOO

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## ABSTRACT

There are 11 species of cranes in captivity in Beijing Zoo, including five rare and endangered species. Experimental research on crane breeding has been conducted since 1964. Now seven species including the red-crowned crane *Grus japonensis*, white-naped crane *G. vipio*, common crane *G. grus*, sandhill crane *G. canadensis*, demoiselle crane *Anthropoides virgo*, West African crowned crane *Balearica pavonina*, and East African crowned crane *B. regulorum* have been bred successfully. Hybrids have also been bred through cross breeding. The method of natural mating and the technique of artificial insemination have been employed alternately in Beijing Zoo. We have observed and recorded accurately mate selection behavior and conditions of mating, courting and copulation, sexual behavior, artificial insemination by the massaging technique, egg laying, incubation, and chick rearing. We have summarized and analyzed the data on sexual maturity, the season of courting and mating, the quality of semen and rate of fertility, the egg laying habits of nine species, the growth and development of chicks and the increase in survival rate of chicks through improved management.

There are 11 species of crane in captivity in Beijing Zoo, including nine species found in China and two species found in Africa. Of these cranes, we have eight black-necked cranes *Grus nigricollis* including three pairs of adults, from the provinces of Qinghai, Guizhou, Gansu, and Sichuan; five Siberian cranes *G. leucogeranus* including two pairs, from the provinces of Jilin, Liaoning, and Anhui; 11 red-crowned cranes including four pairs, from the provinces of Heilongjiang and Liaoning; 13 white-naped cranes including four pairs, from Heilongjiang; 5 hooded cranes from the provinces of Jiangsu; two sarus cranes *G. antigone*, from Srilanka; six sandhill cranes including two pairs from the United States; 12 common cranes including four pairs from Jiangsu Province; seven demoiselle cranes including two pairs from the Inner Mongolia Autonomous Region; two pairs of West African crowned cranes from Sudan; and a pair of East African crowned cranes from Tanzania.

Through natural mating and artificial insemination, cranes have been bred in the Beijing Zoo since 1964. These successfully bred species include the red-crowned crane, white-naped crane, common crane, demoiselle crane, sandhill crane, West African crowned crane, and East African crowned crane. Hybrids have also been bred through cross breeding between the red-crowned and white-naped cranes, the red-crowned and black-necked cranes, and the white-naped and black-necked cranes. The following is a brief introduction to our experiments and research on breeding of cranes.

## BREEDING METHODS

### Choosing a Mate

When adult and subadult cranes are kept in flocks, they can choose their own mates provided they have a spacious enclosure. As soon as two birds begin making unison calls together, they are mated, and should be moved to a separate pen. Rare and endangered species, such as the Siberian and black-necked cranes, and imported species, such as the sandhill crane and the West and East African crowned cranes, are kept separate from the flock. Cranes are monogamous birds; once paired, they will never separate. There have been cases, however, in which one male was matched with two females, with the three birds often calling in unison. If each bird is kept in a separate pen, the females may lay eggs in their respective pens.

### Equipment and Feed

Our cranes are kept on a 2,000 m<sup>2</sup> island. Depending upon their body size, each pair occupies an enclosure ranging from 15 m<sup>2</sup> up. All enclosures are surrounded by wire netting. For cranes whose wings are not pinioned, the enclosure must be covered on top with screen.

Food throughout the year includes breads made of corn flour (30), Chinese sorghum flour (22), wheat flour (5), bran (10), bone meal (1), salt (1), soybean cake meal (23), and maize, vegetables, fish, shrimp, and minced beef.

### Courting and Mating

Spring is the courting and mating season for cranes, when the male bird chases the female, and they run, jump, and sing in unison. Observations conducted periodically on the red-crowned, black-necked, common, and demoiselle cranes confirm that usually the male bird gives the courting call of "ge-ge-ge-ge" before mating. Occasionally, the female spreads her wings, precipitating the male's courting call. When the calling reaches its peak, the male bird mounts the back of the female and copulates with her. Some cranes, however, for example the white-naped and the African crowned cranes, copulate without emitting calls.

### Artificial Insemination

For male cranes not knowing how to copulate or having difficulty in copulating because their wings are pinioned, artificial insemination is the best means of breeding. As for semen collection, one may use the method of massage suggested by Archibald (1974) or Gee and Temple (1978). By massaging the crane's back and thigh, the crane will react by raising its tail. The anus is pressed until semen flows out. Semen may be collected with a funnel or an injector. Massage may also be applied to the female for insemination when she raises her tail. We use physiological saline and PPSE diluent to dilute the semen 1-4 times.

### Egg Laying

Most crane species lay only two eggs in the wild. Under captive conditions, the laying rate may be increased by removing the eggs each time an egg is laid (Nakayama 1967).

### Incubation

Both natural and artificial incubation are used at Beijing Zoo. In the case of natural incubation, the last two eggs are left in the nest for incubation. The eggs can also be incubated by species other than those which are endangered. For artificial incubation, a brooding hen may be used, with each hen taking care of one or two eggs. It is better that each hen take care of one egg. When an incubator is in use, the temperature should be maintained between 36.5° and 38° C with a relative humidity of 50-60%. The temperature for the pipped egg should be around 36°C. Two or three days before the pipping, the eggs are removed to a hatcher. The time between shell breaking and emergence of the chick varies from 14-36 hours. Chicks break open the shell in a clockwise direction. If an egg fails to break open within 36 hours, it is necessary to assist the chick. After finding the position of its beak, a small hole is made at that place and gradually widened until severance is completed. Care is taken not to cause any bleeding during the process.

Chicks are then placed in the hatcher for 24 hours, until their down is dry, and then they can be removed to the brooder box.

### Chick Rearing

Since crane chicks are naturally pugnacious, they must be isolated and reared separately. Kept in neighboring cages, they can see but not touch each other. After about 10 days, fighting will cease and they can be put together again. Still, they should continue to be observed.

Brooder space of 0.5 m<sup>2</sup> per chick is required. Air vents must be open on the front or sides of the brooder. Electric bulbs keep warmth inside and let the chicks choose the temperature freely for themselves. Temperature inside the box should be maintained at 35°C the first week and lowered to 28-30°C the second week, and to 25°C from the third week to the end of the fourth week. Chicks can move more freely inside or outside the room after the first month. Chick rearing in spring is easier than in winter. Winter rearing requires more attention to room temperature, to prevent any abrupt change.

Towels, cloth with rough surfaces and hay can be used to line the bottom of the brooder, which should be kept soft but not smooth. A smooth surface may cause the cranes to slip, precipitating leg problems.

## RESULTS

### Courting and Mating

Healthy pairs of cranes begin to court and copulate in February in Beijing. The earliest copulation occurred between red-crowned cranes on 28 February; the latest, between a pair of common cranes, on 5 July. Most copulation takes place in May. A pair of red-crowned cranes has been observed copulating six times a day. The copulating season of several species of cranes in Beijing Zoo is given in Table 1.

Species	Copulating Season
<i>Grus japonensis</i>	28 February - 20 June
<i>Grus vipio</i>	10 March - 20 June
<i>Grus grus</i>	20 April - 10 July
<i>Anthropoides virgo</i>	15 April - 15 June
<i>Grus canadensis</i>	10 March - 10 May
<i>Grus nigricollis</i>	15 April - 20 June

**Table 1.** Copulating season of cranes in Beijing Zoo.

### Artificial Insemination

Semen of four crane species has been collected. Four eggs from two species of cranes have been inseminated successfully, and three chicks have hatched. The dates of collecting semen, the volume of semen, and the dates of insemination are given in Tables 2 and 3.

A female white-naped crane laid six eggs in 1985. Except for the first egg, the eggs were artificially inseminated. Two fertile eggs resulted from the five eggs inseminated. The time of successful fertilization is probably three to four days from insemination until laying.



## Egg Laying

Sandhill cranes are the earliest of the cranes at Beijing Zoo to lay eggs, beginning 15 March. The latest are black-necked cranes, 15 July and East African crowned cranes, 16 September. There are significant differences in number, size, and color of the eggs of various crane species (see Table 4).

## Incubation

Eggs from the same species of crane and eggs of hybrids have hatched at the zoo. Duration of incubation and body weights of chicks are given in Table 5.

Species	Date	Volume of semen (ml)	Mean volume of semen (ml)
<i>Grus vipio</i>	6 April - 27 June	0.01-0.10	0.04
<i>Grus grus</i>	20 April - 13 July	0.01-0.06	0.04
<i>Grus nigricollis</i>	14 May - 4 July	0.01-0.03	0.04
<i>Grus japonensis</i>	15 May - 15 June	0.02-0.05	0.05

Table 2. Semen collecting dates and volumes for four species of crane 1981-1986.

Date	Semen		Eggs		Number of days between insemination and egg-laying
	Volume (ml)	Quality	Fertile (F)	Infertile (I)	
22 May	0.02	A	F		3
25 May	0.02	A		I	6
31 May	0.04	A		I	5
5 June	0.03	A	F		4
9 June	0.04	B		I	7

Table 3. Artificial insemination dates, semen volume, egg production and fertility of a pair of white-naped cranes, 1985.

A - Innumerable sperm.  
B - Numerous sperm.

Species	Weight (g)	Size (mm)	Color	Spots	Largest number of eggs per year <sup>a</sup>
<i>Grus japonensis</i>	265	105 × 65	greyish white	slight	8
<i>Grus vipio</i>	195	93 × 62	greyish green	dense	9
<i>Grus nigricollis</i>	237	99 × 63	greyish green	dense	12
<i>Grus leucogeranus</i>	248	100.2 × 68	greyish white	freckled at the large end	7
<i>Grus grus</i>	185	93 × 62	greyish white	dense	4
<i>Grus canadensis</i>	180	83 × 55	greyish green	slight	7
<i>Anthropoides virgo</i>	135	87 × 53	grey	separate	4
<i>Balearica pavonina</i>	130	76 × 57	bluish white	none	7
<i>Balearica regulorum</i>	123	85 × 59	bluish grey	none	2

Table 4. The number, weight and features of eggs of several crane species.

<sup>a</sup>From a single female.

Species	Number of days of incubation	Body weight of chick at hatching (g)
<i>Grus japonensis</i>	32 - 33	165
<i>Grus vipio</i>	30 - 32	131
<i>Grus canadensis</i>	28	116
<i>Grus grus</i>	28 - 30	-
<i>Anthropoides virgo</i>	27 - 28	-
<i>Balearica regulorum</i>	28	117
<i>Balearica pavonina</i>	27 - 28	105
Hybrid of <i>Grus nigricollis</i> and <i>Grus vipio</i>	31	158
Hybrid of <i>Grus japonensis</i> and <i>Grus vipio</i>	31	102
Hybrid of <i>Grus japonensis</i> and <i>Grus nigricollis</i>	32	-

Table 5. The duration of incubation and body weight of chicks of several species.

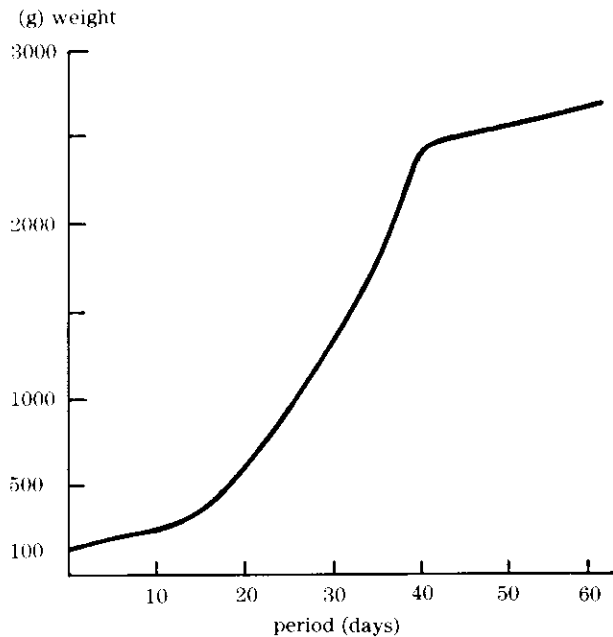
## Chick Rearing

Chicks can exercise freely outdoors only one week after hatching in spring, but ten days after hatching in winter. The legs of chicks must be watched carefully, since a rapid increase in body weight may cause the legs to become deformed and rickety. Along with the right nutrients and constant temperature, the proper amount of exercise is very important for the growth and development of chicks.

Gain in body weight and growth and development of the culmen, middle toe and tarsus are shown in Figures 1 and 2.

## DISCUSSION

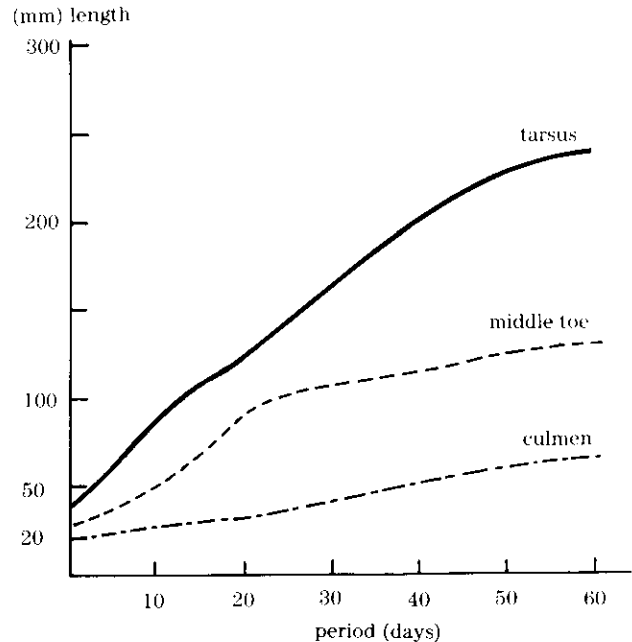
Since the first successful breeding of a red-crowned crane in our zoo in 1965, a total of seven species of pure bred and three kinds of hybrid cranes have been produced here. Data and experiences concerning the breeding biology of cranes, such as the choosing of mates, courting and mating, egg laying and hatching, and chick rearing have been recorded. These results provide useful reference materials pertaining to the breeding of endangered species. Chicks may thus be bred according to plan.



**Figure 1.** Growth curve of an East African crowned crane chick.

Chick rearing is an important link in the process of breeding cranes. The mortality of crane chicks is often high due to improper management. Beside proper temperature and nutrition, an increase in exercise inside and outside the brood house is needed, especially during the winter, for the growth of chick legs.

Maturation dates of various cranes must be understood when they are bred under captive conditions. According to our observations, various cranes reach sexual maturity as follows. Female red-crowned cranes lay eggs from age seven on. Male black-necked cranes copulate from the fifth year, females from the third (we have not yet bred black-



**Figure 2.** Development curve for culmen, middle toe and tarsus of an East African crowned crane chick.

neckeds successfully). A male white-naped crane gave semen at two years of age; quality of semen was very good at three years, when a female laid fertile eggs after being artificially inseminated. Semen can be collected from a common crane when three years of age. A female Siberian crane laid eggs when she was seven.

Research experiments on such procedures as artificial insemination, freezing and preserving of semen and increasing fertility rates, hatching rates, and chick survival rates will be undertaken in the future, when we hope to breed more cranes that are endangered.

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# A STUDY ON THE AMOUNT OF FOOD INTAKE AND ITS MAIN NUTRITIONAL COMPONENTS FOR THE WHITE-NAPED CRANE IN CAPTIVITY

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## ABSTRACT

This paper reports on observations and measurements of the food intake of the white-naped crane *Grus vipio* and the main nutritional components of its food. Data were collected for three captive white-naped cranes from the end of 1982 until summer 1984. Characteristics of food intake were analyzed for different times of year. The largest amount of food was consumed from August until January, and the amount gradually decreased after January. The total intake of vegetable food for a year was greater than for animal food, but animal food intake was greater from January to April.

Managing the white-naped crane in captivity is one strategy for conserving this endangered crane. There have been published studies on the white-naped cranes (e.g., Li et al. 1986), but not on the amount of food intake and its nutritional components. This topic is very important, however, to understanding the cranes' individual growth and development and to improving reproductivity. The author reports on observation and measurements of the amount of food and its main nutritional components of the white-naped crane in captivity between the end of 1982 and the summer of 1984 in Ping Shan Wildlife Farm, Heilongjiang Province.

## MATERIALS AND METHODS

### Sources of Animals

Two birds were captured from the wild in July 1981. A third bird was obtained by artificial incubation of an egg. After a period of feeding in captivity, these individuals developed well and the experiment was carried out under normal physiological indices.

### Kinds of Food

The food was mainly composed of different species of freshwater fish: *Misgurnus anguillicandatus*, *Phoxinus phoxinus*, *Carassius auratus*, etc. Vegetable food included kernels of corn *Zea mays* as the main component, with a small amount of vitamins added.

### Measurement of the Amount of Food Taken

The food was given four to six times a day. Before each feeding, every component of the diet was weighed and then all mixed and given to the cranes to eat freely. Every time after the crane fed, the remaining food was again weighed; the difference between these two weights revealed the amount of food taken by the cranes. The animal food (fish) could easily be separated from the vegetable food. During the experimental period, the cranes were weighed once every 10 days, before the morning feeding.

### Calculations of the Food Intake

The food intake was calculated on the basis of average percentage of dry matter. Fish has 22.2% dry matter and corn kernels have 88.8%. Calories and crude protein in each kind of food were calculated according to the tables of food components published in China (such as Institute of Health 1976; Institute of Animal Husbandry, Chinese Academy of Agricultural Science, and Chinese Society of Animal Nutrition 1985). Some kinds of food were analyzed directly from their components.

## RESULTS AND DISCUSSION

Table 1 shows that the amount of food taken by a white-naped crane per day was 207.3 g, 37% of it was animal food and 62.2% vegetable food. Table 2 shows that the amount of food consumed by a bird in different months of a year varied, the largest amount being consumed from August to January next year, and the amount decreasing gradually after January. As to the ratio between animal and vegetable foods, from January to April, the animal food intake was a little larger than the vegetable food; from May to October, the vegetable food intake was larger than the animal food; during November to December, the two amounts were equal. The total intake of vegetable food for a year was larger than for animal food.

Table 3 shows that the average body weights and the intake of main nutritional components in food varied among months. Both before and after February, the body weight and the amount of food intake were decreasing; from the latter half of April, the amount of food intake increased but the body weight decreased (see Figure 1). The data in Table 2 suggests that the intake of vegetable foods was greater than the intake of animal foods because vegetable foods contain more calories. The calorie intake increased gradually through the year, except between February and April. As stated above, animal food intake was greater than vegetable food intake at this time.

The average caloric intake of the crane was  $662.5 \pm 27.6$  Kcal/day, averaging 0.1 Kcal for every gram of body weight. The average crude protein intake was  $40.2 \pm 3.09$  day, averaging 0.007 g for every gram of body weight.

Many aspects to food and nutritional intake changed before or during the early spring breeding season of the cranes. During early spring in 1983 and 1984, the birds exhibited reproductive behavior which significantly decreased food intake and feeding frequency.

From measurements of food amounts in a yearly cycle, the relationship between physiological needs of cranes and food intake were preliminarily determined. The feeding conditions in captivity altered the crane's behavior from the wild situation. But these data nevertheless provide a basis for an effective nutrition program for white-naped cranes in captivity. There are still problems, such as determination of intrinsic nutritional requirements, that need further study.

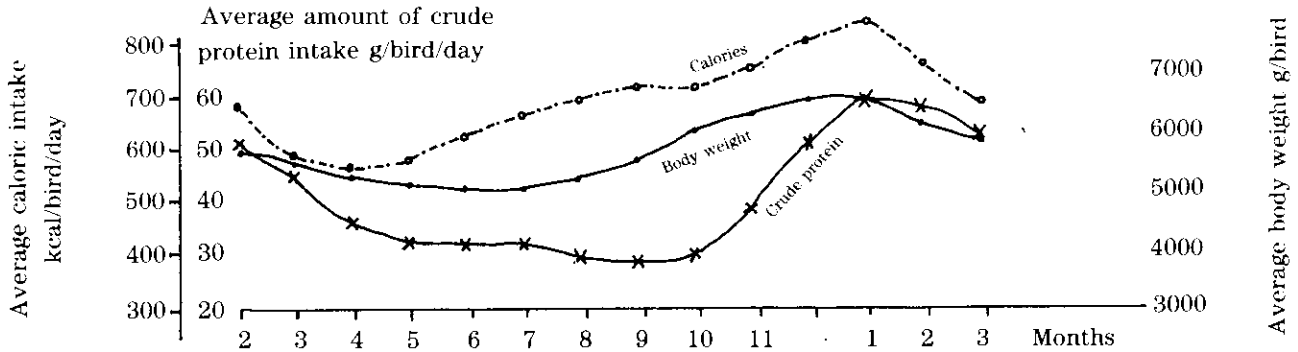


Figure 1. Monthly body weight and intake of calories and crude protein.

	Crane No.	Day										Average food intake (g)	
		1	2	3	4	5	6	7	8	9	10		$\bar{x}$
Animal feed	B <sub>1</sub>	94.9	78.2	98.5	75.3	80.7	68.6	81.4	63.4	62.4	65.1	76.9	78.55
	B <sub>2</sub>	88.3	73.3	89.8	69.2	74.6	173.8	74.5	59.3	58.4	70.3	83.2	
	B <sub>3</sub>	91.9	78.3	97.8	72.9	74.8	63.9	77.0	61.5	69.5	68.9	75.7	
Vegetable feed	B <sub>1</sub>	120.0	150.0	155.0	160.0	160.0	140.5	140.6	141.0	158.7	78.5	140.4	128.77
	B <sub>2</sub>	118.0	145.0	145.0	59.3	150.0	70.3	157.8	74.3	162.5	76.4	115.9	
	B <sub>3</sub>	114.0	145.0	102.0	125.5	152.0	139.5	99.5	136.7	140.8	87.1	130.0	
Average total intake												207.32	

Table 1. Average food intake of three white-naped cranes.

Month	Average food intake dry matter (g)	Animal food (g)	Vegetative food (g)	Average caloric intake (kcal)	Average intake of crude protein (g)	Ratio between animal and vegetable foods
2	186.1	102.3	83.8	635.7	54.9	1 : 0.82
3	149.6	78.1	71.5	591	43.4	1 : 0.90
4	120.8	64.9	55.9	463	34.0	1 : 0.88
5	169.4	63.5	105.9	612	31.6	1 : 1.67
6	156.0	45.7	110.3	607	32.8	1 : 2.40
7	151.0	43.7	107.1	587	31.6	1 : 2.40
8	190.8	53.0	131.8	736	32.8	1 : 2.50
9	189.8	47.1	142.7	672	23.3	1 : 3.00
10	196.4	58.3	138.1	686	27.4	1 : 2.40
11	246.4	122.4	124.4	708	38.9	1 : 1.00
12	205.7	101.2	104.5	783	45.3	1 : 1.00
1	214.3	113.6	100.7	851	63.3	1 : 0.89
2	194.3	111.3	83.0	770	60.9	1 : 0.75
3	136.3	73.7	62.5	554	42.4	1 : 0.85

Table 2. Daily intake of food, calories and crude protein for three white-naped cranes.

	Month												$\bar{x}$		
	2	3	4	5	6	7	8	9	10	11	12	1		2	3
Average body weight	5875	5750	5350	5110	5138	4955	5138	5702	6121	6522	6705	6599	6355	5835	5798.4
Average amount of calories taken per day (kcal/day per bird)	660	591	463	611	606	587	735	672	687	709	783	851	770	553	662.5
Average amount of crude protein taken per day (g/day per bird)	54.9	43.4	34.0	31.6	32.8	31.6	32.8	23.3	27.4	38.9	45.3	63.3	60.9	42.4	40.2
Average amount of calories per g of body weight	0.11	0.10	0.09	0.12	0.12	0.12	0.14	0.12	0.11	0.11	0.12	0.13	0.12	0.09	0.11
Average amount of crude protein per g of body weight	0.009	0.008	0.006	0.006	0.006	0.006	0.006	0.004	0.004	0.006	0.007	0.009	0.009	0.007	0.007

**Table 3.** Average body weight and daily intake for main nutritional components (g).

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## MICROSCOPIC STRUCTURE OF THE FEATHER OF THE RED-CROWNED CRANE

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### ABSTRACT

In this paper, the microscopic structure of different kinds of feathers on the main parts of the rare and precious bird - the red-crowned crane *Grus japonensis* - were reported. Results showed that the barbules of different kinds of feathers vary greatly in morphology and structure. The investigation will provide one basis for bird classification, according to the structure of feathers, and for the identification of relationships among birds.

Feathers are the most complex cuticular derivatives of the integument of birds. Their different parts display an enormous variety of modifications. This difference not only shows in the morphology of feathers, but also, more significantly, in their microscopic structures. The macroscopic and microscopic differences in the morphological structure of feathers vary among the various classification groups, and every classification group has its characteristic feather structures. Even in a species of bird, there are different types of feathers. All these provide the basis for classification on the microscopic structure of feathers, and thus open a new way of scientific research for bird classification, bionics and archaeology.

The red-crowned crane is one of the rare and precious birds in the world. For its preservation, extensive investigations have been carried out on its ecology, physiology, and reproduction. This paper reports on the investigation of the microscopic structure of its different types of feathers under the scanning electron microscope.

### MATERIALS AND METHODS

The materials used in the study were the feathers taken from seven different parts of the bird: 1. remex, barbs from the middle part of the inner vane of the second primary remex; 2. tail feather barbs from the middle part of the inner vane of the second outer rectrix; 3. barbs of contour feathers on the back; 4. down feathers (plumules) on the back; 5. feathers on the lore; 6. feathers on the vertex of the head; 7. feathers on the occiput (back of neck). The sample was first put in a mixture of ether and ethyl alcohol (95%) (1:1) to be thoroughly washed; after drying, the barbules and the remi were taken down under the stereomicroscope. Then the samples were fixed on the stage of the scanning electromicroscope, spraying with gold (Au)

by a vacuum sprayer, and examined under scanning electron microscope.

### THE STRUCTURE OF THE FEATHER AS A WHOLE

According to the principles of classification of Chandler (1916), the feathers of the red-crowned crane can be divided into five kinds:

1. large and strong remiges and rectrices;
2. contour feathers;
3. small down feathers;
4. hairlike filoplumes (the feathers on the vertex of the crane);
5. small bristles on the face.

In general the feather is composed of the shaft and vanes; the shaft in its turn is divided into the rachis and the calamus. The calamus is a tubular structure composed of stratified squamous epithelium, somewhat transparent and never pigmented, largely implanted in the feather follicle. At the lower end of the calamus, there is a pore called the inferior umbilicus, through which the pulp enters during the growing period of the feather; when the feather is completely mature, the inferior umbilicus is closed.

The rachis is the long, essentially solid portion of the shaft above the skin. In the rachis is the pith, consisting of a firm spongy tissue, formed from large, polygonal epithelial cells. Because the pith is filled with air, the rachis is opaque. The division between the rachis and calamus is marked by the superior umbilicus on the ventral surface of the shaft. The rim of the superior umbilicus often carries an after feather. On both sides of the rachis, there are vanes formed from barbs. The vanes on either sides of the remiges and rectrices of the red-crowned crane are not symmetrical, the angle between the inner barbs and rachis being larger than that of the outer barbs. The vanes on the two lateral sides

of the rachis are not on the same plane, but the number of barbs on either sides are similar: 635-648 for remiges, 337-338 for rectrices, and 102-111 for contour feathers. The density of barbs (number of barbs per unit length of the rachis) is greatest at the base of the rachis, decreasing to the tip. On contour feathers, there are 39-46 per cm at the base, 18-21 at the middle, and 15-17 at the upper part. The number of barbs at the base of the rectrices is 22-24 per cm, 16-18 at the middle, and 13-15 on the upper part. The number of barbs on the remiges at the base is 34-36 per cm, 14-16 at the middle, and 11-12 on the upper part.

A barb is composed of a ramus and barbules, which are different according to the type of function of the feather.

#### THE MICROSCOPIC STRUCTURE OF BARBULES

There are four types of barbules of the red-crowned crane: distal, proximal, plumulaceous and spine-like barbules.

##### Distal Barbules

This kind of barbule is found on the middle and upper part of barbs of remiges, rectrices and contour feathers. It consists of a wider base with several oblique stripes and a pennulum. The ratio of the length between the base and the pennulum is different for different kinds of feathers: 1:1.1 for remiges, 1:1.21 for rectrices, 1:1.392 for the middle and upper parts of contour feathers.

At the tip of the pennulum, there are the spine-like dorsal cilium and ventral cilium, which occur in pairs, but they are not completely symmetrical, the ventral cilium being slightly longer than the dorsal. The number of pairs of cilia on the remiges is 6 (rarely 7), 11 pairs for rectrices, and 9-10 pairs for the middle and upper parts of contour feathers. The cilium is wider at the base, but gradually narrower to the tip. The length of the cilium gradually increases from the tip of the pennulum to the base. At the base of the pennulum, there are hooklets composed of three parts: a short base at a small angle from the pennulum; a long and bending middle part, hanging steeply, even vertically from the pennulum, and a short, thickened, hooked tip. The hooklet at the base of the pennulum is the shortest, and the hooklets become gradually longer to the apical part. At the same time, the angle to the pennulum also increases gradually. Since the hooklets project at different angles, their tips span a greater distance than the base. The number and length of the hooklets vary with different kinds of feathers. On remiges, there are 6 (rarely 7), on rectrices, 7, and on the middle and upper parts of contour feathers, 5 (Figures 1, 3).

On the ventral surface of the base, there are ventral teeth. Every tooth is a process of a cell. The number of ventral teeth on the rectrices is 2, the same on remiges, and on the middle and upper parts of contour feathers are 3.

##### Proximal Barbules

These barbules occur on the remiges, rectrices and the middle and upper parts of contour feathers, and are also composed of the base and the pennulum. The division of the base and the pennulum is set by the distal border of the outmost cells that bear a ventral tooth, and thus the ventral teeth are believed to be parts of the base (Chandler 1914; Sick 1937).

The base has several stripes, and is wider (the width at the widest is 89.209 $\mu$ m for remiges, 85.56 $\mu$ m for rectrices, and 50 $\mu$ m for the middle part of contour feathers). The base usually consists of several fused cells; the traces of their nuclei are circular. The lines of division of these cells are oblique to the longitudinal axis of the base, so the base has several stripes. The dorsal border is called the dorsal flange, which is slightly recurved to the ventral side. At the distal end of the flange are dorsal spines, which are low, pointed processes slightly recurved to the ventral side. The number of dorsal spines on both remiges and rectrices is 3. At the proximal end of the barbule, there are ventral teeth on the ventral side, 5 for remiges, 4 for rectrices, and 3 for the middle and upper parts of contour feathers. The ventral teeth are much larger than the dorsal ones, the largest being in the middle; a tooth is a protrusion of a cell.

The pennulum is narrower than the base, and consists of several internodes, 6-7 for remiges, every internode being a pennulum cell (Oehme 1963), and the base of the internode is swollen, called a node with two spines. The length of the spines is different for different kinds of feathers: 7.285 $\mu$ m for remiges, 11.75 $\mu$ m for the middle and upper parts of contour feathers. The diameter of the cell of the pennulum base is larger than that of the top, but the length of the cells is gradually shorter to the top. Though the length of proximal barbules varies according to the kind of feather, the length ratio of the base and the pennulum of the proximal barbules on different kinds of feathers varies significantly. The pennulum of proximal barbules on the middle and upper parts of contour feathers is significantly longer than that of remiges and rectrices. The length ratio of the base and pennulum is approximately 2.2:1 for contour feathers, 2.78:1 for remiges, and 2.5:1 for rectrices. The pennulum of the proximal barbules of the middle and upper parts of contour feathers has 11-12 long cells—the internodes. The node has 2 nodal prongs significantly longer than those of remiges and rectrices (Figures 2, 4).

The distal and proximal barbules attach to either sides of the ramus of the barb, the distal barbules at the distal part and the proximal ones at the parts near the base, so the names. The position of the distal barbules is higher than the proximal ones, and this arrangement is advantageous to their connection.

On a vane, the hooklets of the distal barbules hook onto the dorsal border of several proximal barbules nearby, thus forming the integral vane (Figure 18).



### Plumulaceous Barbules

This kind of barbule occurs on the entire plumule (down feather) and on the barbs at the base of contour feathers and the feathers of the occiput, the vertex and the lore. This barbule is fluffy and loose, and is composed of several, somewhat differentiated cells. Its flexible, flat and short base consists of 2-3 fused cells and its pennulum, of several long cells. The base of every pennulum cell swells to form the node, which has 5-6 outgrowths called the nodal prongs.

When the feathers are slightly worn, the plumulaceous barbules often break at the joints of pennulum cells. The length of the internodes, their diameter, and the number and length of nodal prongs can be used as one of the categories for interspecies classification (Chandler 1916; Hargrave 1965; Messinger 1965; Richnen and Cunningham 1978). The mean values of the diameter of plumulaceous barbules of the red-crowned crane are  $8.060\mu\text{m}$  for the down feathers, and  $5.721\mu\text{m}$  for the base of contour feathers. The ratio of mean values for the length of nodal prongs and internodes is 0.529:1 for down feathers on the back, and 0.250:1 for the base of contour feathers (Figures 10, 11, 12, 14, 15, 17).

### Spine-like Barbules

The spine-like barbules are found on the vertex, occiput, the lore and the barbs on the middle and upper parts of the contour feathers. The base is longer and wider than that of the plumulaceous barbule, the widest on the occiput is  $13.5-16.5\mu\text{m}$ . The length of the internodes is shorter than for plumulaceous barbules and is  $30-35\mu\text{m}$  on the occiput,  $26.3\mu\text{m}$  on the vertex. Two long spines grow out from the base of every node; the spines are longer than the length of the internode:  $39-42.3\mu\text{m}$  for the occiput,  $55.10\mu\text{m}$  for the vertex, and the spine of the spine-like barbules of the vertex is the longest.

The base is flat and wide, 2-2.5 times that of the pennulum (Figure 13).

### MICROSCOPIC STRUCTURE OF THE RAMUS OF BARBS

The ramus of remiges and rectrices is of the shape of a compressed filament that tapers in width from base to tip. The base of the ramus is somewhat wider, called the petiole. On the ventral surface of the border between the petiole and the ramus is a notch. The ramus bears the barbules on either side: the concave surface of the ramus bears the distal barbules, the proximal barbules occur on the convex surfaces. Cross sections of the rami have the shape of crescent moons. The rami of barbs consist of two layers: the cortex and the pith (Figure 6).

On the surface of the cortex, there are dense cuticular protrusions, with penta- or hexa-polygonal spots, the longer side of which is parallel to the ramus of the barb, called the tegmen. At the center of every spot, there is a circular concave surface. The arrangement of spots is regular, and their size gradually decreases from the base to the tip (Figure 5).

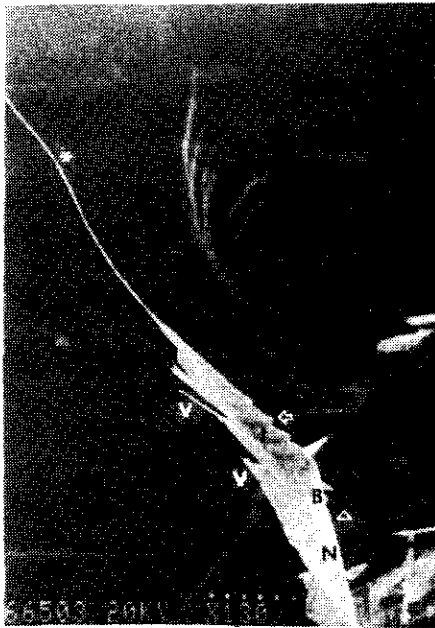
The cells of the cortex are compactly arranged, and the cortex is the hard part of the ramus, and contains pigment (Figure 9).

The pith has a pith wall, which is formed by pith cells. The pith wall divides the pith into many air chambers, which are filled with air. The chamber is of irregular polygonal shape or nearly elliptic (Figure 7). The pith wall is porous, and contains pigment (in colored feathers). The pith walls form the skeleton of the barbs. This structure not only strengthens the very thin barbs, but also decreases the weight of the feathers because air fills the pith, and is thus advantageous to flight (Figure 8).

In this experiment we also observed that the cross section of the pith of the rami of barbs and the pith of rachises are discontinuous. The barbules and the rami of barbs are also discontinuous, but became attached during development. All these matters need further study.



**Figure 1.** Scanning electron micrograph of the distal barbule of remiges:  
base (B); ventral tooth (V); hooklet (H); ventral cilium (†); and dorsal cilium (Δ).



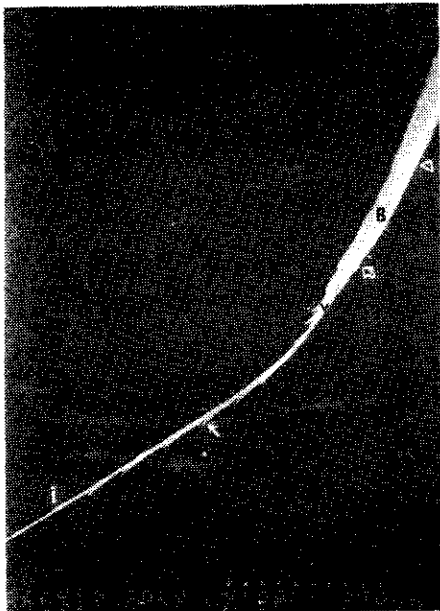
**Figure 2.** Scanning electron micrograph of the proximal barbule of remiges:

base (B); ventral tooth (V); dorsal flange ( $\Delta$ ); and pennulum with nodal prong (\*). The cell border of the base ( $\dagger$ ) and the nucleus (N) are clear.



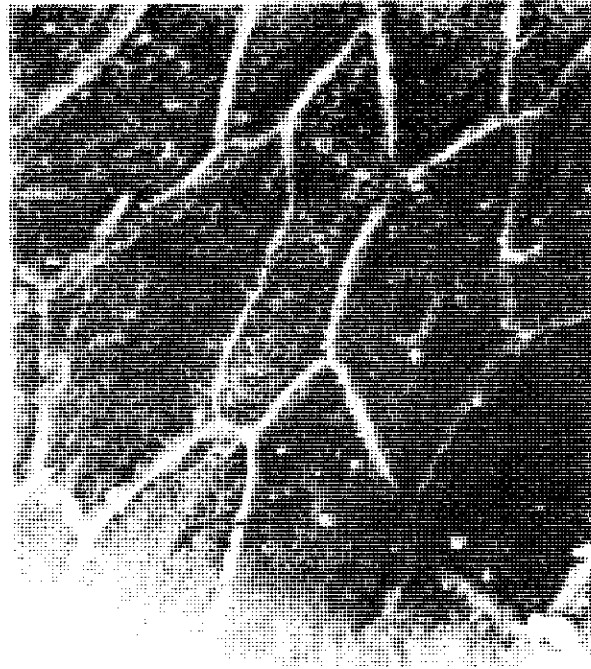
**Figure 3.** Scanning electron micrograph of the distal barbule of the contour feather:

base (B); ventral tooth (V); hooklet (H); ventral cilium ( $\dagger$ ); and dorsal cilium ( $\Delta$ ).



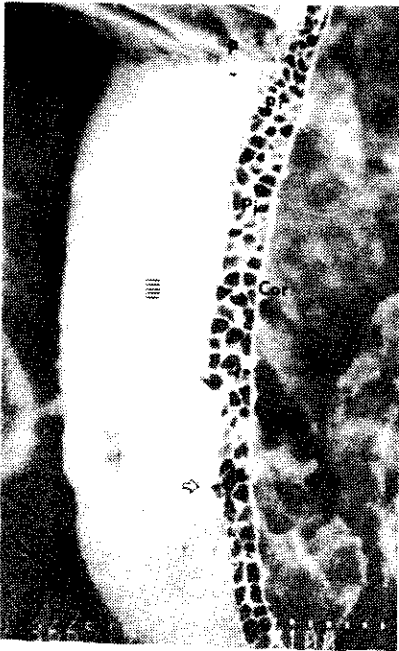
**Figure 4.** Scanning electron micrograph of the proximal barbule of the middle and upper parts of the contour feather:

base (B); ventral tooth (V); dorsal flange ( $\Delta$ ); dorsal spine ( $\theta$ ); dorsal cilium ( $\dagger$ ); and ventral cilium (i).



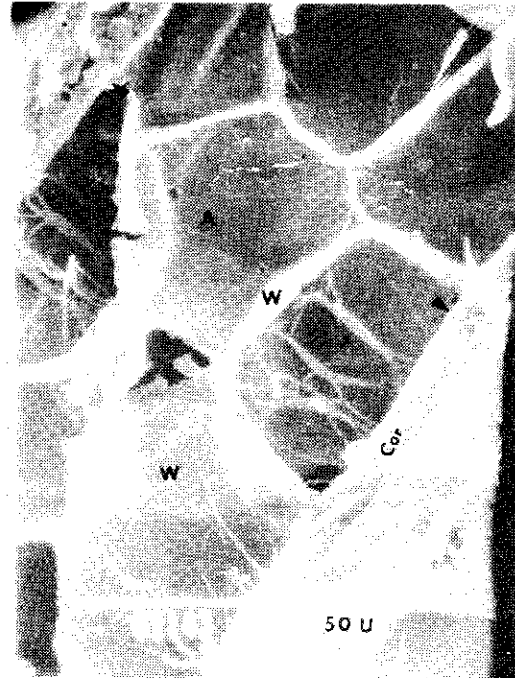
**Figure 5.** Scanning electron micrograph of the pattern on the surface of the ramus of remiges.

Penta- and hexa-polygonal spots are on the surface of the ramus, a circular concave surface ( $\dagger$ ) on each spot, with dense cuticular protrusions ( $\Delta$ ).



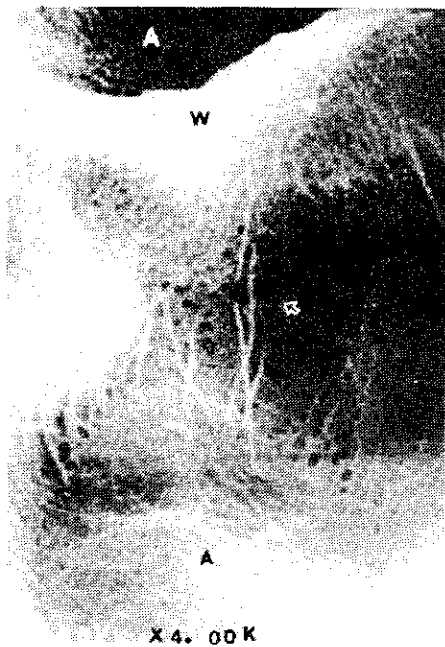
**Figure 6.** Scanning electron micrograph of the cross section of the ramus of the barb of remiges:

proximal barbule (P) attaching to the convex surface ( $\equiv$ ); distal barbule attaching to the concave surface. The ramus consists of cortex (cor) and pith (pi). There is a pattern ( $\phi$ ) on the surface of the cortex.



**Figure 7.** Scanning electron micrograph of the longitudinal section of the ramus of remiges:

air chamber (A) in the cortex (cor); pith ( $\blacktriangle$ ); and wall of pith (w), porous and thin, with cuticular fibers ( $\dagger$ ).



**Figure 8.** Scanning electron micrograph of the air chamber of the pith of the ramus of remiges:

air chamber (A); and the porous ( $\phi$ ); wall of pith (w); and the cuticular fiber on the wall ( $\blacktriangle$ ).



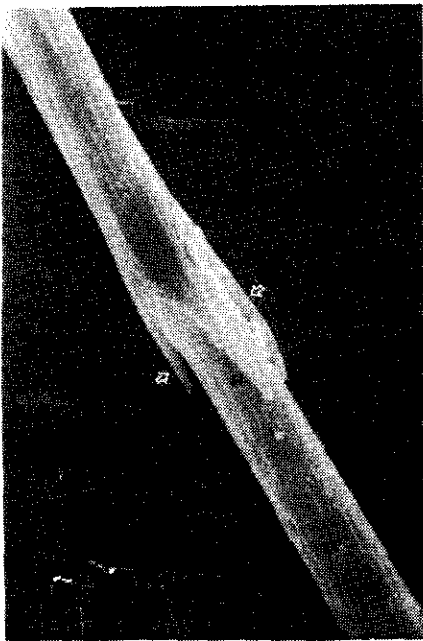
**Figure 9.** Scanning electron micrograph of pigment granules at the tip of the secondary remex; pigment granules are of elongated elliptic shape (p).



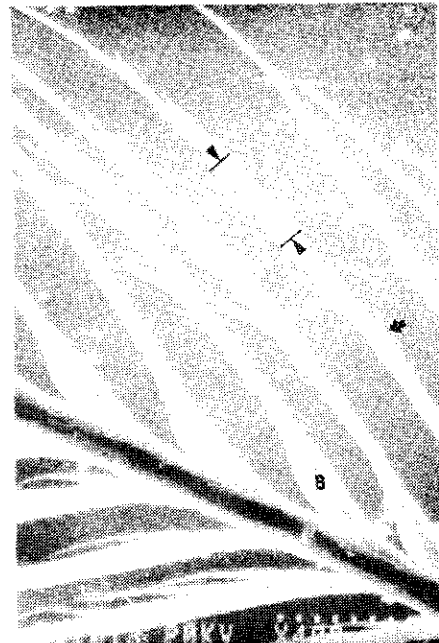
**Figure 10.** Scanning electron micrograph of the arrangement of plumulaceous barbules of plumules on the back:  
base of the plumulaceous barbules (B), twisted by 90° after emerging, arranged on the ramus (x).



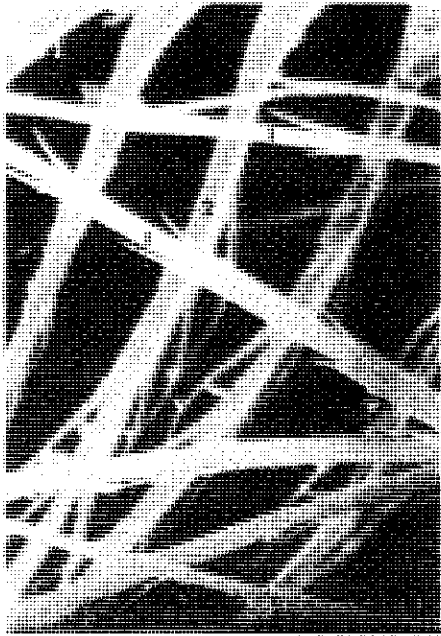
**Figure 11.** Scanning electron micrograph of plumulaceous barbules of plumules on the back:  
the pennulum is formed by the connection of several long slender cells; the base of each cell swells to form the node (n). Nodal prongs (†) grow from each node.



**Figure 12.** Scanning electron micrograph of plumulaceous barbules of plumules on the back:  
nodal prongs (†).



**Figure 13.** Scanning electron micrograph of the spinelike barbules of the occiput feather:  
base (B) flat and wide, nodal prong very long (†), internode shorter (↔).



**Figure 14.** Scanning electron micrograph of the plumulaceous barbules on the base of occiput feathers:  
spikelike barbule (2); and plumulaceous barbule (1).

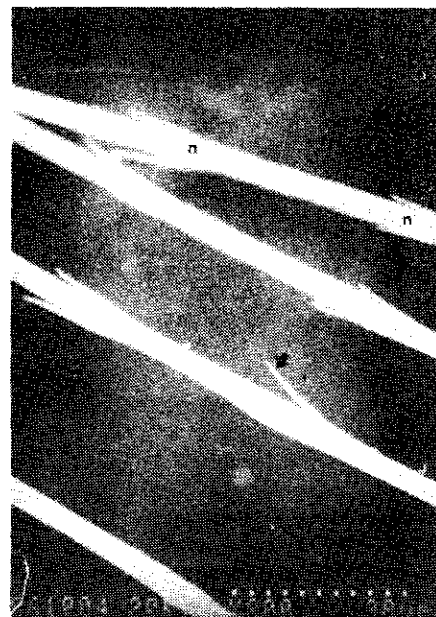


**Figure 15.** Scanning electron micrograph of the plumulaceous barbule on the lore:  
node (n); internode (n-n); and nodal prong (†).

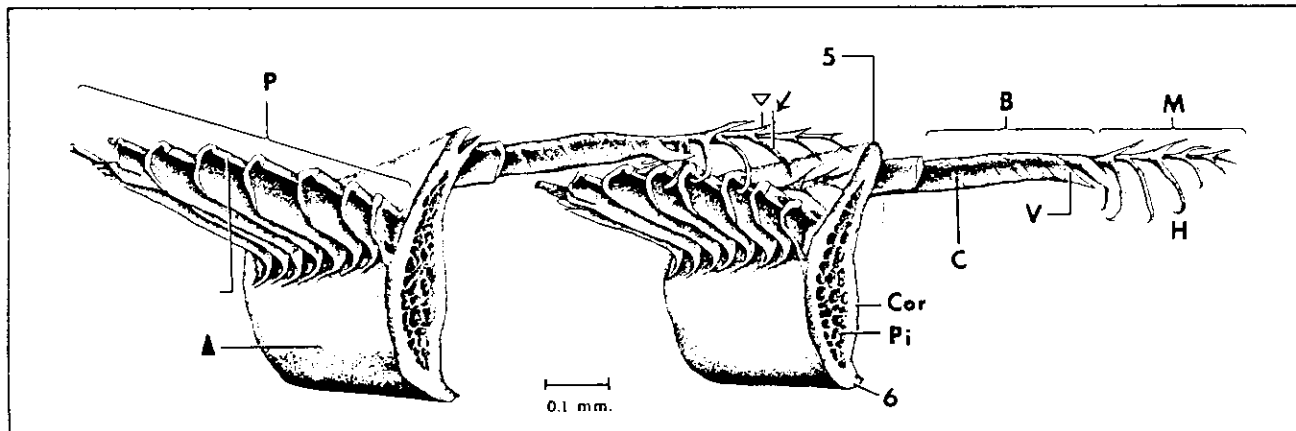


**Figure 16.** Scanning electron micrograph of the filoplume and the papillae (E) on the crown of the red-crowned crane.

The vertex of the crane's head has numerous papillae in which there are large numbers of blood vessels and a sinus, red in color when alive, with a small number of filoplumes ( $\Delta \phi$ ).



**Figure 17.** Scanning electron micrograph of the plumulaceous barbule at the base of the contour feather:  
node (n); internode (n-n); and nodal prong (†).



**Figure 18.** Pattern of interlocking for the distal proximal barbules.

The base (B) of distal barbules is formed by several cells with clear borders (c), and the cells at the distal end protrude to form ventral teeth (v). The pennulum (M) consists of the hooklet (H), the dorsal cilium (▽), and the ventral cilium (∩). Proximal barbules (P) attach to the convex surface (▲). The ramus divides into cortex (cor) and pith (pi), dorsal ridge (5) and ventral ridge (6).

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## THE MICROSCOPIC STRUCTURE OF THE FEATHER OF CRANES IN CHINA

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### ABSTRACT

This paper reports results of an electron microscope study of the microscopic structure of the main kinds of feathers of the nine species of Gruidae in China. Interspecific differences are significant, and especially the plumulaceous barbule has important significance for classification. Characteristics of feathers of Gruidae are listed.

The classification of birds so far is based on the external morphological traits, and the morphology and color of the plumage. In addition to these traits, the classification of cranes also refers to the bending pattern of the trachea, but the whole and intact specimen is needed for these classifications. In many circumstances, such good specimens are difficult to obtain, while the feather is the most easily obtained of materials. Therefore, the identification of birds using the morphology and microscopic structure of feathers becomes necessary, in some instances, the only alternative. This method can also be supplementary to the morphological and biochemical ones.

Using the microscopic structure of feathers as the criteria for classification has been studied in some countries. Chandler (1916) reported on the microscopic structure of feathers, and indicated that the microscopic structure, especially the structure of barbules, had potential significance for classification. Auber (1957) also indicated that the identification of the extent of the pigment precipitation pattern for orders of birds has important significance in phylogeny. Reany et al. (1978) reported that electron microscopy of 15 species, of 4 families of 2 orders of birds, showed the complexity and variability of feathers of birds; they used the differences in the microscopic structure for the study of the classification of birds. Day (1966) constructed a key of orders of birds on the basis of feathers. Madame Raybael (name transliterated) of the National Museum in Washington, D. C. studied the microscopic structure of the fragments of feathers from the engines of airplanes, and identified the species of birds impacting on the airplanes. These studies indicated that classification of birds on the basis of the microscopic structure of the feather is feasible and useful. Thus a new means of classification of birds is opened up and will be helpful to the studies of archaeology, bionics and medical jurisprudence. The microscopic structure of feathers can be used to identify the relationships among birds. With the

development of the technology of electron microscopy, the study of the structure of feathers will be further advanced.

This paper reports results of a study on the morphology and structure of feathers of the nine species of cranes in China. The differences between species were discovered, giving a basis for the classification of birds using the microscopic structure of feathers.

### MATERIALS AND METHODS

The nine crane species in China are:

1. Red-crowned crane *Grus japonensis*
2. Black-necked crane *G. nigricollis*
3. Common crane *G. grus*
4. Sarus crane *G. antigone*
5. White naped crane *G. vipio*
6. Sandhill crane *G. canadensis*
7. Hooded crane *G. monacha*
8. Siberian crane *G. leucogeranus*
9. Demoiselle crane *Anthropoides virgo*

The materials used in this experiment were taken from four different parts of each of these nine species: remiges, the distal barbules and proximal barbules of the middle of the inner vane of the second primary remex, also the rami of the second primary remex; tail feather, distal and proximal barbules of the middle of the inner vane of the second outer rectrix; the spinelike barbules of the occiput feather; and the plumulaceous barbules of the plumule on the back.

The materials were first put in a mixture of ether and ethyl alcohol (95%) and thoroughly washed; after drying, the materials were dissected under the stereomicroscope. Then, these materials were fixed on the stage of the electron microscope, sprayed with (Au) gold by a vacuum sprayer, and examined under scanning electron microscope.

## RESULTS

The vane of remiges and rectrices consists of distal and proximal barbules; the down feathers, of plumulaceous barbules, and feathers on the occiput, of spinelike barbules (for the morphological structure of these types of barbules, see Jing et al., this proceedings). This paper compares and provides measurements of the nine species of cranes. The results indicate that there are distinct differences among species (see Table 1, Figures 1-12).

The microscopic structural characteristics of the feathers of Gruidae are as follows.

### Microscopic Structure of Remiges

(1) Distal barbule: hooklets 6-7; ventral teeth 2-3; cilia 4-10 pairs.

(2) proximal barbule: ventral teeth 2-5; dorsal spines 3 (rarely 4) (see Figures 1, 2, 3, 4).

(3) On the surface of rami, there are penta- or hexagonal spots, the long axis of which is parallel to the axis of rami. Every spot has a circular concave surface, with dense cuticular protrusions.

(4) The structure of the pith of rami: the pith is divided into many polygonal air chambers by the porous walls made of longer cuticular fibers, with long elliptical pigment granules inside.



**Figure 1.** Scanning electron micrograph of the distal barbule of the remiges of the demoiselle crane:

ventral cilium (†); dorsal cilium (Δ); hooklet (1); ventral tooth (V); and base (3).

### Microscopic Structure of the Rectrices

(1) Distal barbules: hooklets 5-7; ventral teeth 2-3 (rarely 4); cilia 6-8 pairs.

(2) Proximal barbule: ventral teeth 4-6; dorsal spines 3 (rarely 4).

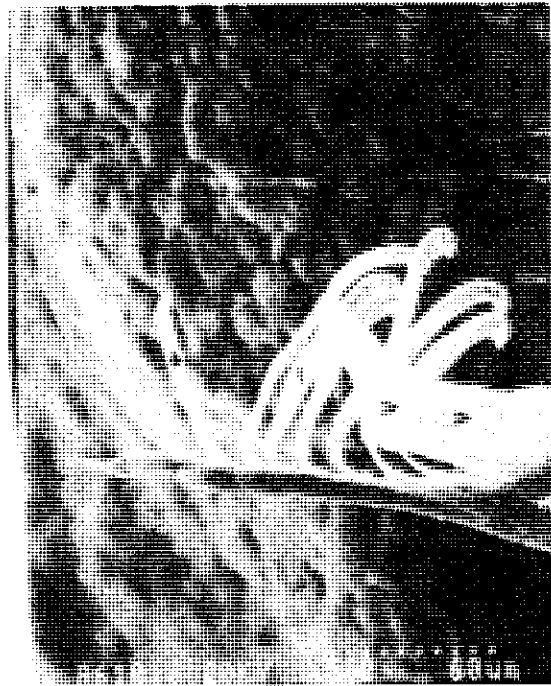
(3) The spots on the surface of rami and the structure of pith are the same as those on the remiges.

### Down Feathers on the Back

The down feather consists of plumulaceous barbules; the nodal prong is shorter and the internode longer, the ratio of length between them is 0.155-0.529 : 1. The diameter of the internode is more or less the same along the length, its mean is 3.174-5.728 μm (Figures 8, 9, 10).

### Feathers on the Occiput

The hase consists of plumulaceous barbules, the morphology and structure of which are similar to these of down feathers on the back. The middle and upper parts of these feathers consist of spinelike barbules, the nodal prong of which is very long, but the internode is relatively short; the ratio between them is 1.479-2.820 : 1. The diameter of the internode decreases to the tip, the mean diameter of the second internode is 5.625-9.612 μm. (Figures 11, 12).



**Figure 2.** Scanning electron micrograph of the distal barbule of the remiges of the white-naped crane:

ventral cilium (†); dorsal cilium (Δ); hooklet (1); ventral tooth (V); and base (3).



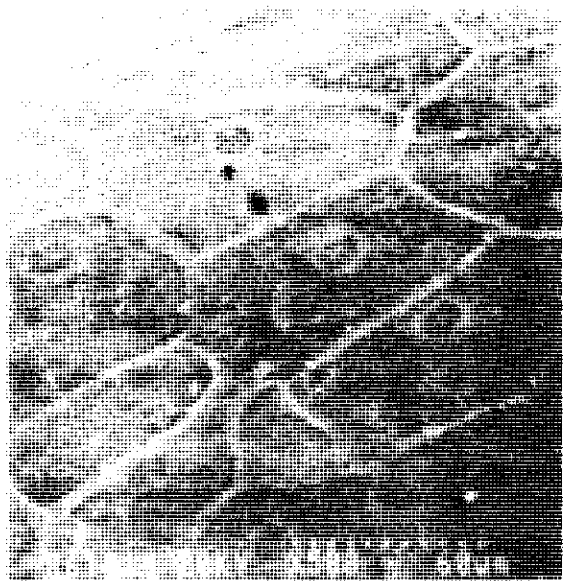


**Figure 3.** Scanning electron micrograph of the proximal barbule of remiges of the white-naped crane, consisting of pennulum (\*) and base. The pennulum has several nodes and internodes, with some nodal prongs; every internode is a cell, the nucleus is clear. Other symbols are the same as Figure 4.

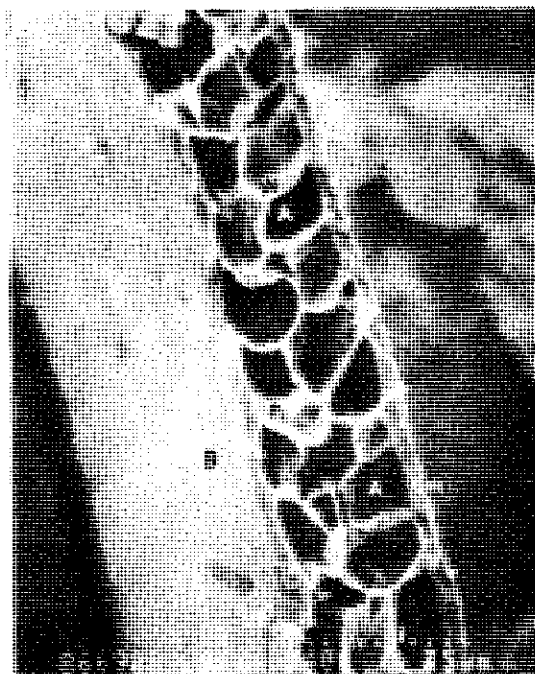


**Figure 4.** Scanning electron micrograph of the proximal barbule of the remiges of the black-necked crane.

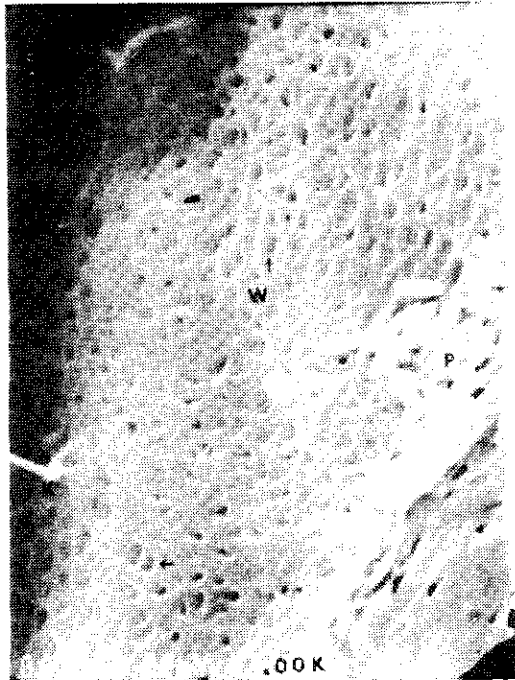
The base consists of several cells with clear borders (▲) and nuclei (N); the distal cells protrude to form long and slender ventral teeth (V). On the back, there are dorsal flanges (†) and dorsal spines (Δ).



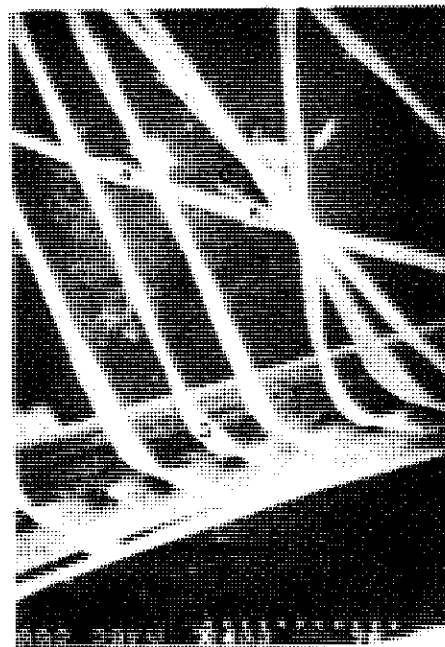
**Figure 5.** Scanning electron micrograph of the surface spots of the ramus of the remiges of the white-naped crane. The spots are penta or hexa-polygonal, with the long axis parallel to the axis of the ramus; within the spot, there are dense cuticular protrusions (Δ) and a circular concave surface (†).



**Figure 6.** Scanning electron micrograph of the longitudinal section of the ramus of the remiges of the black-necked crane, formed by the cortex (cor) with markings (B) on its surface and the pith (pi), air chamber (A), and wall of pith (W), with pigment granules in the pith.

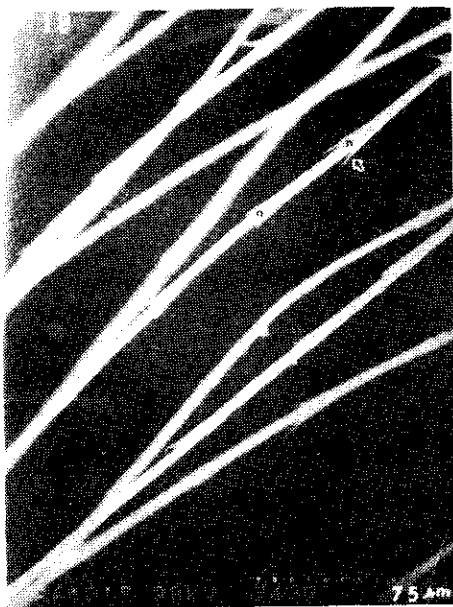


**Figure 7.** Scanning electron micrograph of the wall of pith and pigment granules of the pith of ramus of the black-necked crane. The wall (W) is porous (†) with cuticular fibers (K); in the pith, there are long elliptical pigment granules (P).



**Figure 8.** Scanning electron micrograph of the arrangement of plumulaceous barbules on the ramus of the down feather on the back of the red-crowned crane.

After emergence of the barbules, their hases (3) twisted 90° along the ramus (X), thus making the down feather more loose; node (n), and nodal prong (ϑ).



**Figure 9.** Scanning electron micrograph of the plumulaceous barbule of the down feather on the back of the red-crowned crane, consisting of several long cells with nodal prongs (ϑ). The base of the cell swells to form nodes (n); between two nodes is the internode (n-n).



**Figure 10.** Scanning electron micrograph of the nodal prong of the plumulaceous barbule of the down feather on the back of the sarus crane.

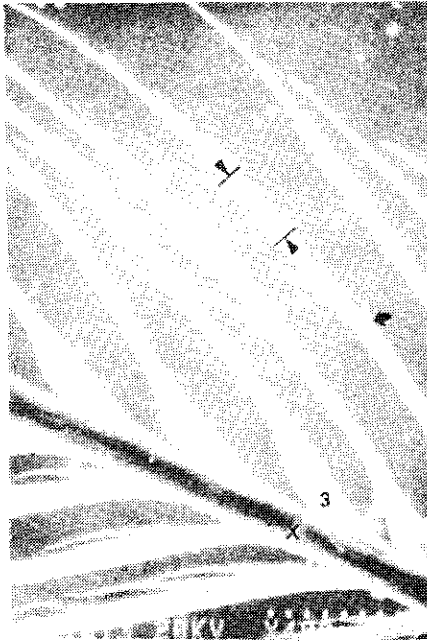
From every node protrudes 3 nodal prongs (†).

Feather Name of Species	RETRICES					REMIGES				
	Distal Barbules			Proximal Barbules		Distal barbules			Proximal Barbules	
	Number of Hooklets	Number of Ventral Teeth	Number of cilia (pairs)	Number of Ventral Teeth	Number of Dorsal Spines	Number of Hooklets	Number of Ventral Teeth	Number of Cilia (pairs)	Number of Ventral Teeth	Number of Dorsal Spines
<b>Red-crowned crane</b>	7	3	8	4	3	6	3	6	5	3
<b>Common crane</b>	7	3-4	8	6	3	7	3	6-7	5	3
<b>Hooded crane</b>	7	3	6	5	3	6-7	2-3	5	5	3
<b>White-naped crane</b>	5	2	6	5	3	7	2	4-5	2	3
<b>Black-necked crane</b>	5	2	7-8	5	3	6	3	6	4	4
<b>Sarus crane</b>	7	3	9	5	3	6	2	6	5	3
<b>Sandhill crane</b>	7	3	8	4	3	6-7	3	6	4	3
<b>Siberian crane</b>	7	2	7	5	4	7	3	6	5	3
<b>Demoiselle crane</b>	7	3	8	5	3	7	2	10	5	3

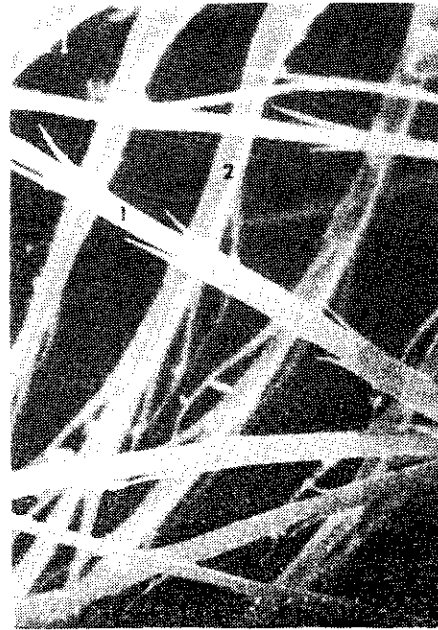
  

Name of Species	FEATHER	Surface marking on the ramus	Structure of the pith of the ramus	Plumulaceous barbules of down feathers on the back		Spinelike barbules of the feather on the occiput	
				Diameter of internodes	Ratio of the length of nodal prongs and internodes	Diameter of internodes	Ratio of the length of nodal prongs and internodes
<b>Red-crowned crane</b>		Penta- or hexagonal markings with the long axis parallel to the axis of the ramus; at the center of the marking is a circular concave surface and dense cuticular protrusions	The pith is divided by porous walls with cuticular fibers, into many polygonal air chambers	5.625	0.529:1	8.060	2.820:1
<b>Common crane</b>		Same as above	The pith is divided by porous walls with cuticular fibers, into many polygonal air chambers; in the pith there are pigment granules	5.728	0.520:1	9.612	1.479:1
<b>Hooded crane</b>		Same as above	Same as above	3.1744	0.418:1	8.308	2.240:1
<b>White-naped crane</b>		Same as above	Same as above	4.742	0.263:1	7.688	1.880:1
<b>Black-necked crane</b>		Same as above	Same as above	4.892			
<b>Sarus crane</b>		Same as above	Same as above	3.742	0.367:1	6.400	1.635:1
<b>Sandhill crane</b>		Same as above	Same as above	3.33	0.115:1	5.625	2.314:1
<b>Siberian crane</b>		Same as above	Same as above	3.744	0.303:1	8.735	2.014:1
<b>Demoiselle crane</b>		Same as above	Same as above	4.842	0.155:1	11.804	1.775:1

**Table 1.** Comparison of the microscopic structure of feathers among species of cranes in China.



**Figure 11.** Scanning electron micrograph of the spinelike barbule of the feather on the occiput of the red-crowned crane: base (3) flat and wide; nodal prong very long (↑), internode (■) shorter; ramus (X).



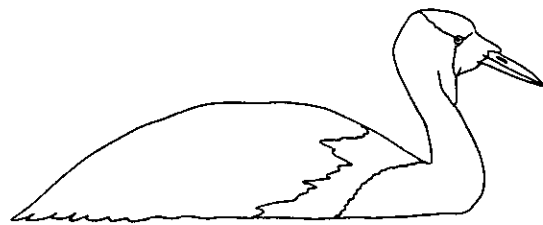
**Figure 12.** Scanning electron micrograph of barbules at the base and on the middle and upper parts of the feathers on the occiput of the red-crowned crane.

At the base of the feather are plumulaceous barbules (1), and on the middle and upper parts are spinelike barbules (2).

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CHAPTER 6  
ABSTRACTS OF OTHER CHINESE PAPERS  
PRESENTED AT THE WORKSHOP





## DIFFERENCES IN BREEDING BEHAVIOR BETWEEN THE MALE AND FEMALE OF THE RED-CROWNED CRANE<sup>a</sup>

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### *ABSTRACT*

Eight pairs of the red-crowned crane *Grus japonensis* (four wild and four domesticated) were studied during the three breeding seasons from 1984 to 1986. The male is the main guard while breeding. Nest-building is started by the male and he picked most of the nest materials. The site is determined by the female and she also helps construct the nest; incubation is mostly done by the female. When attacked by a predator, the female takes the chick into the marsh, while the male lures the enemy in the opposite direction.

<sup>a</sup> complete paper published in China in 1987

## THE ELECTROPHORESIS STUDY OF SERUM PROTEINS, LDH AND ESTERASES OF BLACK-NECKED CRANES

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### ABSTRACT

Electrophoretic techniques are currently being applied to many basic problems in population genetics and evolution biology. They have been demonstrated to be a powerful tool in understanding population ecology and taxonomy. These methods have been little utilized in the rare and endangered species because materials have not been easily obtained. In this paper, we examined serum proteins, lactate dehydrogenases and esterases of black-necked cranes *Grus nigricollis* by gel electrophoresis of samples from three individuals (two females and one male). Peripheral blood samples were collected from Weining Ecology Research Station of Biology Institute of Guizhou. The cranes were all adult. Samples preparation, gel electrophoresis and histochemical stain were performed using methods described by Siciliano and Shaw (1976), slightly modified. Results showed that there were 15 protein bands and 5 LDH isozymes resolved from black-necked crane blood samples. No significant differences of LDH among cranes were observed. There is probably a polymorphism in esterases. Our preliminary study, summarized above for three black-necked cranes, thus presents the first accumulation of biochemical genetics data for the species.



## DISTRIBUTION AND ABUNDANCE OF THE BLACK-NECKED CRANES IN CHINA

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### ABSTRACT

This paper presents the distribution and numbers of the black-necked crane *Grus nigricollis* in China. It is the result of surveys made in Qinghai, Gansu, Xizang, Yunnan, Sichuan, and Guizhou Provinces during 1984-1986 by the authors. The black-necked crane breeds in the Qinghai-Xizang Plateau and winters in the valley of the middle reaches of the Yaluzangbu River and on the Yunnan-Guizhou Plateau. Its distribution includes: in the north from Aerjin Mountain, Xizang to the Himalaya Mountains in the south and in the west from Kalakunlun Mountain to the east to Wumeng Mountain, between 26-38°N and 78-106°E. The altitudinal distribution of breeding cranes ranges from the lowest part of Wulan County, Qinghai Province at 2950 m to Bange, Xizang at 4900 m. The wintering areas include the lowest part of Weining, Guizhou at about 2170 m above the sea to the highest part in Sajia, Xizang about 3900 m. The numbers of black-necked cranes were counted during the winter. From the winter of 1984 to the spring of 1985, there were 701 birds: 412 birds in the middle reaches of the Yaluzangbu River, Xizang, 63 birds in Zhongdian in Hengduan Mountain in the northwest part of Yunnan, 226 birds in Weining, Guizhou. From the winter of 1985 to the spring of 1986, there were 658 birds: 300 birds in the middle reaches of the Yaluzangbu River in Xizang, 58 birds in the Zhongdian district in Yunnan Province, 35 birds in Huize district in the northeast part of Yunnan Province, and 265 birds in Weining district of Guizhou Province. As the census dates are all different, and since some black-necked cranes were not counted, the total number of black-necked cranes in China is estimated at about 800 birds.

## THE DISTRIBUTION OF RED-CROWNED CRANES IN CHINA DURING THE MING AND QING DYNASTIES (1368-1911)

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### ABSTRACT

In order to ascertain the historical distribution of red-crowned cranes *Grus japonensis* in China, the author has made a survey of about 2,200 local chronicles compiled mainly in Ming and Qing Dynasties, dealing with the events of eastern and middle parts of China. Of these sets, 390 sets were found to contain records of cranes. In accuracy and detail, the local chronicles can be roughly divided in five types. In type 1 there are detailed descriptions of the appearance, common behavior, habitat, range and some legend of the red-crowned crane. In type 2 there are no aforesaid descriptions but records of "white crane" or "xianhe" that are other vernacular names of the species. For the birds catalogued in type 3, there are crane records without any specific description. Other species such as common crane *G. grus* and demoiselle crane *Anthropoides virgo* are included in type 4. There is no crane record in type 5. The local chronicles of type 1 and 2 indicate the distribution of the red-crowned crane in the districts concerned at the time when the books were compiled. Type 4 and 5 suggest the opposite conclusion. It is not easy to judge from the type 3 catalogues whether the recorded crane was the red-crowned crane or not. Indirect proofs are necessary in this situation. Red-crowned cranes apparently bred in the marshlands of northeastern China southward to the Delta of Liao River. That was a sparsely populated area and had little human interference during the Ming and Qing dynasties. This species spent the winter in the grassy tidalflats between the Yangtze Delta and Huai River and marshlands of middle and lower Yangtze, mainly in the Jiangnan (Yangtze and Hanshui River) Plain and some around Dongting and Poyang Lakes. The coastal land, including Chongming Island and Lixiaohe District which lay on the coast during the Song Dynasty (960-1279), has remained the main wintering ground of the species since ancient times. The coastal habitats were changed, due to the development of the Yangtze Delta and the eastward shifting of the coastline as well as coastland reclamation. When the cranes breeding in northeastern China approached Shanhaiguan (Hebei) they diverged into two paths. The east group flew along the coastline of the Bo Sea and Huang Sea to the coastal wintering areas. The west group (west of the boundary between the north China Plain and the Yan mountain) migrated to the middle and lower Yangtze. Those cranes breeding along the Mudan River, the upper course of the Second Songhua River and along the Yalu River, upon reaching the mouth of Yalu River, also might have divided into two groups, with some birds migrating along the west coast of the Korean Peninsula and others probably traveling along the coast of China to the southern coastal wintering ground.

WETLAND TRANSITION AND CRANE PROTECTION IN MOMOGE  
NATURE RESERVE OF ZHENLAI COUNTY, JILIN PROVINCE

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*ABSTRACT*

Momoge Nature Reserve for cranes and rare birds lies on the west bank of the lower reaches of Nen River at 130 to 150 m above sea level within the boundaries of Zhenlai County, Jilin Province. There is smooth terrain, with many swamps, marshes, small lakes and reed ponds that occupy about 20% of the total areas. It has been historically the breeding and resting places for cranes and many kinds of aquatic birds. In the 1970s, crane breeding ceased and the diversity and numbers of other birds decreased because average annual precipitation was reduced by about 100 mm. Several rivers in this county dried up and so did most of the lakes, swamps, marshes and reed ponds. Since the beginning of the 1980s, bird use of the area has increased as recent precipitation has filled the rivers, and water has flowed into the swamps, marshes, small lakes and reed ponds. Therefore, in the spring and autumn of each year (from March to May, and from October to November), a hundred Siberian cranes *Grus leucogeranus* and great flocks of white storks *Ciconia ciconia* can be seen in this area as well as some red-crowned crane *Grus japonensis*, white-naped crane *G. vipio*, hooded crane *G. monacha*, common cranes *G. grus*, demoiselle crane *Anthropoides virgo*, and other kinds of aquatic birds. In the spring of 1986, we found nests of the red-crowned crane and white stork (one nest for each species). They had not bred in this area during the previous ten years. As the wetland ecosystem has been gradually restored, cranes and other varieties of aquatic birds have returned.

## TRAINING OF CRANES

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### *ABSTRACT*

Cranes have an instinct for defense reaction. They guard their nests carefully but may damage their eggs to the detriment of their reproduction. After a period of special training, cranes will dance, showing off their beautiful feathers when they hear passwords given by the trainer. This relaxation of cranes is advantageous not only to reproduction but also to allow artificial insemination and the treatment of diseases. At the beginning of the program, the cranes are trained as follows.

First the cranes must be very hungry. The trainer feeds them with various insects that the cranes like while speaking to them a regular password. This makes the cranes attach themselves more strongly to the trainer. Cranes dance and call when the trainer gives them a regular password. Another password for encouragement is given when they have finished their performance. After training, cranes will dance and call as soon as they hear the password. Cranes recognize various passwords as signals even if the password is spoken softly or loudly. They never confuse the passwords.

## OBSERVATIONS ON WINTERING BEHAVIOR OF RED-CROWNED CRANES AT YANCHENG NATURE RESERVE<sup>a</sup>

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### ABSTRACT

From 1983 to 1985 the author made detailed observations on the wintering behavior of red-crowned cranes *Grus japonensis*. This species spends more than four months in coastal wintering grounds of Yancheng, from late October to early March. The cranes usually gather in three types of flocks: family groups, nonbreeder groups and groups mixed with other species such as common crane *G. grus*, little egret *Egretta garzetta*, grey heron *Ardea cinerea*, bean goose *Anser fabalis* and so on. The plant foods taken by the birds during the wintering season are seeds of salt-tolerant species (e.g., *Carex scabrifolia*, *Suaeda salsa*), and roots, leaves or stems of grasses and reeds. Animal foods that they seem to prefer include crabs and small fishes (e.g., *Bullacta exarata*, *Ruditapes philippinarum*, *Solen gouldii*, *Sesarma* sp., *Nereis* sp., *Lingula anatina*). The cranes also feed on wheat or corn when it is provided on freezing days. The size of the wintering flock grew yearly through protection efforts, from 420 birds in the winter of 1982 to 476 in 1984. There are other wintering groups, beyond the tidal marshes of Yancheng, in Chongming Island, Guannan County and in Guanyun County.

<sup>a</sup> complete paper published in China in 1987

## A KARYOTYPE ANALYSIS OF THE BLACK-NECKED CRANE

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*ABSTRACT*

The chromosomes of the black-necked crane *Grus nigricollis* have been examined by culturing peripheral lymphocytes. There were three cranes (two females and one male) analyzed. They were all from Weining County, Guizhou, China. The species has been found to be a karyotype  $2n = 80$ . The karyotype consists of five autosomal pairs and one sex chromosome pair as the macrochromosomes, and a large number of microchromosomes. Sex chromosomes are heteromorphic in females permitting sexing by means of chromosome analysis. Measurements of relative lengths and arm ratios of the macrochromosomes were also made.

## A STUDY OF ARTIFICIAL INCUBATION OF RED-CROWNED CRANE EGGS

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### *ABSTRACT*

In the years 1981-86, we artificially incubated 37 eggs of the red-crowned crane *Grus japonensis*. There were 35 zygotes in the eggs. Twenty-four hatched (77.4%) and 70.8% of the chicks survived. During the entire incubation period, the temperature, humidity, turning over of eggs, and cooling of eggs have been carefully manipulated. Weight loss of eggs, stages of incubation, incubation periods, and hatching behavior have been observed.

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## A FINDING OF COMMON CRANES IN HUBEI PROVINCE

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### *ABSTRACT*

According to the literature, the common crane *Grus grus* breeds in the northeast provinces and the west of Xinjiang in our country, and also winters in the southern area of the Yangtze Valley. During December, 1980 to February, 1981 and December, 1981 to February, 1982, the author often found at dusk ten to several dozen common cranes. The birds gathered in the wheat fields of Honghu County located on the northern bank of the Yangtze where they ate wheat seedlings. Furthermore, in Yanwo district of the above-mentioned county, the author saw a little girl pick up a common crane killed in the wheat fields in February, 1982.



## OVERWINTERING OF RED-CROWNED AND SIBERIAN CRANES IN CHINA<sup>a</sup>

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### ABSTRACT

The wintering of red-crowned cranes *Grus japonensis* and Siberian cranes *G. leucogeranus* was studied from 1979 to 1984. The winter habitat of the red-crowned crane was predominantly the coastal area of the East Sea in Jiangsu Province in the winter of 1979. In addition, other wintering areas of red-crowned cranes were scattered along the south shore of Poyang Lake, Jiangxi Province and Shijiu Lake, Anhui Province. The wintering districts of red-crowned cranes are within 28°30'-34°N and 116°-121°E. Family groups including two adults and one or two chicks, as well as flocks of near 100 birds, were encountered. The wintering period is about four months, from late October to late February of the next year. There are about 500 red-crowned cranes wintering in China. The great flock of 737 Siberian cranes, including 107 young birds, was observed in Poyang Lake, Jiangxi Province.

<sup>a</sup> complete paper published in China in 1985

STUDY OF NATURAL CONCENTRATION AND DISTRIBUTION OF  
SOME METALLIC ELEMENTS IN EGGS AND FEATHERS OF THE  
DEMOISELLE CRANE IN CHINA

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JIANG ZUCHENG and CHENG ZHUJUN

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*ABSTRACT*

The feathers and eggs of the demoiselle crane *Anthropoides virgo* were collected in China during May to December, 1986. The inductively coupled Plasma-atomic Emission Spectrometric method was used to determine levels of Fe, Mn, Mg, Cr, Al, Ca, Cu, Na, and Zn in abdominal feathers, neck feathers and eggs. The following conclusions are drawn from the results. 1) The above mentioned elements were found in the feathers and eggs of the demoiselle crane, but the concentration of each varied in distribution. 2) The concentration of metals differed between abdominal feathers and neck feathers. 3) The concentrations of Ca, Fe, Al, Mg, Cu, and Zn in feathers from the abdomen and the neck were estimated to be 1-100 times higher than concentrations in the yolk and shell of the eggs.

## A COMPARISON OF THE STERNUM AND THE PECTORAL GIRDLE IN FOUR SPECIES OF CRANE

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### *ABSTRACT*

Twelve skeletons (seven red-crowned crane *Grus japonensis*, one white-naped crane *G. vipio*, two hooded crane *G. monacha* and two Siberian crane *G. leucogeranus*) were studied for the present paper. Through the comparison of the sternum and the pectoral girdle, notable differences were found between the Siberian crane and the other three species of crane. The measurements of the sterna and the pectoral girdles of the four species of crane are included in this paper.

## CRANES OF DALINOR LAKE IN INNER MONGOLIA

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*ABSTRACT*

Dalinor (43°14'-43°23'N, 116°23'-117°E) is situated in Inner Mongolia. There are four species of crane, red-crowned *Grus japonensis*, white-naped *G. vipio*, common *G. grus* and demoiselle *Anthropoides virgo*. Among them, the red-crowned, white-naped, and demoiselle cranes breed at Dalinor, the westernmost breeding place for red-crowned cranes in China. In autumn (October) more than 100 white-naped cranes concentrate in one group for migration. They leave Dalinor for the south about 25 October every year. We have investigated this area for three years from 1983 to 1985. The number of demoiselles is more than the number of white-naped cranes. Demoiselles leave Dalinor earlier than other cranes, at the end of September.

## ACHIEVEMENTS AT LONGSHAR PARK, QIQIHAR, IN THE MANAGEMENT OF CRANES

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### *ABSTRACT*

Cranes have been reared in captivity in Qiqihar for at least 190 years, and for the last 80 years they have consistently been maintained at Longshar Park. Quite appropriately, Qiqihar is called "The Home Town of the Crane." The history of crane and crane habitat protection is reported. Cranes were hand-reared and trained to display. When they died, money was collected for their tombstones. Six species of wild cranes can be seen near Qiqihar and all of these have been maintained at Longshar Park. Seven red-crowned cranes were reared at Longshar Park between 1967-72 from eggs laid at the Park. Between 1985-86 five white-naped cranes were reared from eggs produced at the Park.

## THE RED-CROWNED CRANE IN XINGKAI (KHANKA) LAKE

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LI WENFA

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### ABSTRACT

The distribution of red-crowned cranes *Grus japonensis* was investigated in Xingkai Lake during 1984 to 1986. These censuses of breeding cranes were carried out in May of three years, when all the cranes had settled on their own territories after arriving here from the south. The results of the censuses were as follows: 72 individuals and 19 nests were registered. Nine cranes and two nests were located in small Xinkai Lake district. Forty-three cranes and 12 nests were in Laocan-  
dui. Four birds, and two nests were in the Sungacha Basin. Twelve cranes and three nests were in Lian. Through the three censuses of 1984 to 1986, we determined the number in this flock has kept at the same level. The authors believe this flock and the Xingkai (Khanka) flock in USSR belong to the same population and suggest that China cooperate with USSR in studying these birds in the future.

## A PRELIMINARY STUDY ON THE TERRITORIAL BEHAVIOR OF THE RED-CROWNED CRANE

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### *ABSTRACT*

The territorial behavior of the red-crowned crane *Grus japonensis* was observed from March to May in 1985 and March to October in 1986 in Zhalong Nature Reserve. Territories are very large, and the size of territory is correlated with the density of the population. The territory of the wild cranes is usually the largest before egg-laying (average size 3.55 km<sup>2</sup>) and smallest in the incubation period (average size 1.86 km<sup>2</sup>). During the brooding period it expands to 2.93 km<sup>2</sup>. The unison call is not only used as a synchronizer between pair members, but it is also a signal for territorial defense. Upon the invasion of other cranes, and according to the intensity of the stimulus, the length of the unison call increases, and at the same time the cranes raise their wings to threaten the invader. This threat includes bowing and arching. The appearance and sequence of the posture depends upon the intensity of the stimulus. The territory of the red-crowned overlaps with that of the white-naped crane, but their feeding niches do not overlap. Sharp conflict between the two species was not observed.

THE FIRST REPORT OF BREEDING OF THE COMMON CRANE IN  
LINDIAN, HEILONGJIANG, CHINA<sup>a</sup>

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*ABSTRACT*

On 11 May 1986, a nest and two eggs of the common crane *Grus grus* were found in Huluxing of Lindian County of Heilongjiang Province. This is a new breeding area for the common crane and extends the known range south from 51°N to 47°N. The nest was built in reed marshes and was made from *Carex*, reeds, and other materials. The external diameter of the nest was 105 x 100 cm, the internal diameter was 64 x 58 cm, the weights of two eggs were 160.5 g and 157.1 g respectively, and the lengths of the eggs were 89.25 x 57.9 mm and 88.9 x 57 mm respectively.

<sup>a</sup> complete paper published in China in 1987



## THE STUDY OF BREEDING TECHNIQUES FOR BLACK-NECKED CRANES

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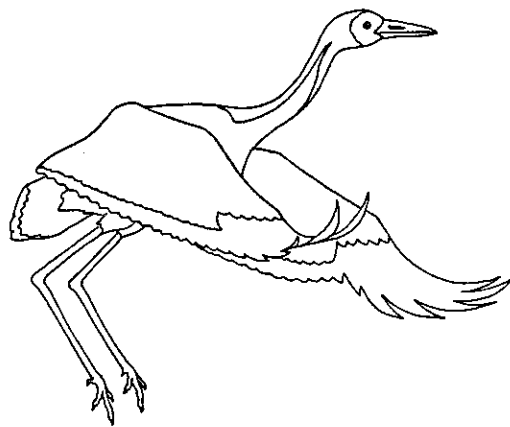
Xining People's Park, Xining, Qinghai, China

### ABSTRACT

This paper deals with the development of breeding techniques for black-necked cranes *Grus nigricollis* in captivity. The experiment was conducted using eight black-necked cranes (five male and three female) in the zoo of Xining People's Park, Qinghai Province. To simulate the normal physiological and reproductive functions of the wild black-necked cranes, we raised and conditioned wild black-necked cranes, paired them artificially, provided living conditions simulating those in nature, and used a feeding method considered not only to be nutritionally complete but which copied the way the cranes gather food in the wild. As a result, the black-necked cranes mated, laid eggs, incubated them and reared chicks. For the first time, two black-necked cranes were reared in captivity. The young cranes are healthy and behaviorally normal.

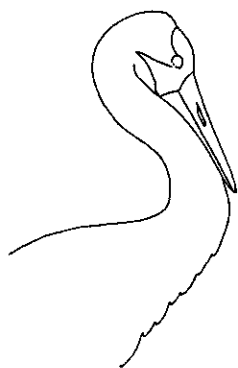


PART II. INTERNATIONAL PAPERS





CHAPTER 7  
GENERAL CONSERVATION, BEHAVIOR, AND METHODS





# PRESERVING WETLAND VALUES FOR PEOPLE AND WILDLIFE

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## ABSTRACT

Wetlands, areas where water causes a recognizably different plant cover to develop, are highly productive ecosystems which are part of the earth's freshwater storage and supply systems. They support many unique forms of plants and wildlife, and improve the quality of waters flowing through them. Humans often destroy wetlands for short-term benefits and then suffer long-term consequences, such as flooding and soil erosion, without appreciating how the two events are linked. Wetlands buffer climatic extremes for wildlife, and are in themselves esthetically pleasing landscape features which will attract tourists to view them. Wetlands protection depends upon both (1) sound governmental policy and (2) thorough education of the local people using wetlands. Sustainable wetland uses, based upon ecologically sound local actions, have global impacts in terms of enhancing world ecosystem stability.

## CHARACTERISTICS

Wetlands are places on the land where water lingers in significant quantity for a long enough time to cause features to develop that set these sites apart from other land areas (Nickerson 1978). One of these visible features is the vegetative cover, composed of plants that can tolerate water around their roots for long periods of time (up to three years) without apparent harm. Another less visible feature is the soil that develops under these waters. Finely divided organic matter, which is slow to decay owing to a lower oxygen concentration, may accumulate under water in depths up to several meters. It is primarily the water, however, that distinguishes a wetland, and the source of that water determines what type of wetland is formed (Motts and Heely 1973).

A *water-receiving wetland*, even if large, is generally a settling basin for waters which flow into it from higher land around it, either as rain and runoff, or as groundwater seeping out along its upper edges. It characteristically develops deep muds and/or peats, and its water surface is generally quite still. Often a hardpan or water-holding layer is developed in the soil below this wetland type, because inflowing water percolates downward to become part of the groundwater.

A *water-producing wetland* is formed at the site of a continuous subterranean groundwater upwelling; water continually leaves the area by a series of rills or by a more or less well-defined stream. These wetlands often serve as unfailing supplies of clean water for humans.

The two forms may be found together, with water outflow dominating during one part of the year, and water inflow dominating during the other part of the year. The important fact is, however, that they remain wetlands as long as water is present; they never change, or "succeed," into dry upland, in spite of all the erroneous statements about such a succession pattern in ecology textbooks (Drury and

Nisbett 1973). Depending upon age and extent of sediment and mud consolidation, these wetlands first support herbaceous emergents, then herbaceous edge fringes and floating edge mats of vegetation, and finally at a still later time, water-tolerant shrubs and forest trees.

## CLEANSING POWERS

Water is necessary for wetlands, and its flow is regulated by the wetland in several ways. A thick cover of vegetation physically retards water flow, slowing down floodwaters and thus at least temporarily impounding them. Slowed water quickly deposits its silt load, so that vegetated wetlands produce cleaner water by simply slowing up moving water. This thick mantle of vegetation also keeps sunlight away from the water surface, thus keeping water temperatures lower and lowering water loss by evaporation in drier times (Maltby 1986).

Because water runs more slowly through a vegetated wetland system, it takes time for water to get to the lower discharge point. The slowing of water makes it more probable that all water flowing through a wetland will, in the course of its transit, come in contact with finely divided organic matter as well as with the roots of living plants. Growing plants will extract most of the fertilizer elements from the water and even in winter, bacteria living anaerobically on the organic matter will denitrify water flowing over them very quickly and efficiently (Bartlett et al. 1979). Most organic pesticides and herbicides as well as a number of heavy metals will be absorbed onto the small organic particles, or may be taken up by some plants (Nickerson 1978). Another remarkable result is that polluting coliform bacteria and human enteroviruses are mostly removed during passage of fecal-contaminated water through a wetland (Maltby 1986). What emerges is cleaner and purer water than what went in. All these cleansing processes are not

visible, but are very real wetland functions which are to the immediate and ongoing benefit of humanity, especially when they occur on any streams that serve as a human water supply or source of recreational swimming waters.

### PRODUCTIVITY

Wetlands can be characterized as being highly productive ecosystems because they build quantities of organic matter, utilizing minerals that enter them directly through growth of their plants, and indirectly by selective adsorption of polluting materials onto their organic particles. It is this lush plant growth and subsequent decay into detritus (tiny particles of organic matter) which feeds tiny animals; they in turn are fed upon by larger animals and they in turn are fed upon by certain bird species, such as herons. Other birds, such as most cranes and many species of duck, are largely vegetarians, directly eating quantities of the plant material produced by wetlands (Maltby 1986).

Wetland vegetation, while dependent upon water, also depends on fluctuation of the water level over time for its survival. Permanent flooding kills trees. Deep water remains open as a lake or pond because of "fetch", or wind-generated wave action. The shallower water areas, with levels which rise and fall rhythmically during a year's cycle, are the important part of these productive, cleansing, and stabilizing inland ecosystems.

### ENVIRONMENTAL BUFFERING

People generally do not dwell in wetlands, which may be a reason for the tranquility and quiet solitude often associated with these ecosystems. Wetlands are often visited to enjoy these very attributes (Madson 1986). Animals and birds are often found concentrated in and around wetlands, where they may feed and breed relatively undisturbed. Wildlife of many kinds cannot exist without access to these wetlands because wetlands offer their own characteristic habitat ameliorations at different times of environmental stress throughout the year. Wetlands are cooler in hot weather, calmer in windy weather, unfrozen or warmer in cold weather, and wetter in dry weather. Wetlands act as buffers in the range of environments with which all wildlife must cope to survive. Since wetlands serve different kinds of wildlife at different times of the year, however, it is not possible to find all wetland-dependent animal species of an area present in any one of its wetlands at any one time.

A different amenity that wetlands offer is the fact that their presence adds to the quality of life for all humans. Just knowing the open space is there, and that cranes and other creatures exist because of that open space, makes wetlands rather special parts of our total ecosystem (Madson 1986; Manson 1986).

### VALUES OF NETWORKS OF WETLANDS

Together, wetlands and wildlife form an interactive system; every wetland is important because these areas are bound together through common uses by populations of the same bird or animal at the same time. A single small

wetland preserved as an ecosystem example is next to useless; the strength of the wetland-wildlife interaction depends on the network of wetlands developed in nature. Variations do occur in size of wetlands, and a very few really large ones exist at different places throughout the world. Their large size makes them even more precious, because there is then room for existence of environmental gradations which specially adapted wildlife species can utilize to advantage at different times (Lamb 1984). Thus every hectare of these larger wetlands, just as with every hectare of smaller ones, is uniquely valuable at some time of the year to some species. Reduction in size of any wetland by whatever means results in increased stress on its wildlife inhabitants, a change in its water regime, and a slow but inevitable change in its vegetative cover (Thibodeau and Nickerson 1985; Nickerson and Thibodeau 1986).

### DESTRUCTION AND DRAINAGE

Destroying wetlands will surely mean destroying far more than their transient wildlife inhabitants. At the same time, doing away with wetlands by drainage or filling will not materially lessen the water flow into the area. The main result of such destruction is creation of aggravated flood conditions at one time of year and aggravated drought conditions at another time of year. A natural wetland modulates extremes of the water inflow-outflow curve; it moderates the environmental stress periods.

If these wetlands are truly important to us as people (and they are), why, one may ask, have they been traditionally regarded as worthless wastelands, fit mostly for filling (often with trash), dredging, damming, or cutting over? Wetland protection is really a matter of overcoming ignorance and greed by education (Briceno and Drake 1986). Traditional clearing, farming, and replanting practices do not work in the long run for wet areas. Drained water must go somewhere, and if it is forcibly concentrated, it often becomes a torrent rather than a gentle, slow-moving stream. Furthermore, fertility of the drained areas does not last: once accumulated organic matter is exposed to oxygen, it is rapidly decayed by bacteria, and the basis for high crop yields is gone. The soil can only be replenished by once again letting it become an underwater and thus anaerobic repository for organic material for a long period of years.

### IMPOUNDED WATER

Dammed water, so enticing as a graphic method for prevention of downstream flooding and as a possible source of electrical power as well as an abundant irrigation supply, has drawbacks seldom thought about (Jackson 1984). When water is slowed, its silt load is dropped, as noted above. Dams abruptly halt fast-moving water. Many dams have had useful life spans of only 20 years before deposited silt completely filled their water-storage areas. Others, mistakenly built in nearly level country, simply transfer the floodwater upstream. The only way to assure longer dam life is to slow erosion rates to as near zero as possible in an entire catchment area. How many examples exist in



the history of dam-building where land management to lower the catchment erosion was the first consideration? It is generally a complete afterthought which becomes necessary as the dam begins to trap silt.

Irrigation water derived from the reservoir is not "pure," but has in it dissolved salts (chlorides and sulfates in particular) which accumulate on the surface and in the upper soils of irrigated fields because water evaporation leaves them behind. Depending on concentrations of these salts in the water, and they are always more than zero, the lifespan of irrigated fields is only 20-30 years; after this time, these accumulated salts render the fields unuseable for conventional agriculture (Jackson 1984). Once again, long-term effects are more costly to the human environment than the short-term gain.

### FISHERIES VALUES

River systems also have fish living in them. The base of their food chain is invariably plant material. If sunlight does not penetrate into the river's waters because of silt turbidity, then the foodchain base is curtailed, and ultimately fish of harvestable size are both smaller and fewer in number. Wetlands, by cleansing water, have great importance. Furthermore, intact wetlands often serve as egg-laying and nursery areas both for these river fish and those organisms on which they feed. Significant parts of most open-water rivers and lakes are the wetlands that border some or all of their shores. It is these areas of vegetation-choked shallow waters, accessible from deeper waters, which are indispensable to a thriving fishery.

Deliberate rapid draining of a wetland or lake, even periodically, completely removes food fish — young fry and as well parent fish — and quickly leads to low yields of native fish in the area (Maltby 1986). Many river fish do not migrate far from the area of their hatching; thus new fish, unlike new water, do not continually flood into the lower reaches of a stream from upstream. Fish are really localized products. The quality and quantity of their local wetlands and connecting waters determine their abundance.

### WETLANDS MANAGEMENT

The way in which wetlands are treated (managed) by humans determines their attractiveness and uses as recreational areas as well as their sustained productivity. Local uses of wetlands are often centuries old; the recent rash of wetland problems has developed because of human population increases and either a common belief that the "old" ways, developed when far fewer people were present, are still perfectly all right to pursue, or a faith that we can do what we like using modern technology, because we can easily replace what we destroy. There is no scientific evidence to indicate that replacement, or re-created, wetlands work like natural ones. We now know that the main limit to biological production of animal life is ultimately the size and reliability of its photosynthetic plant base. There is little room to maneuver. Plants must first trap the sun's energy before it is available to build and maintain animal

bodies. This limit on animal production is called the *carrying capacity* of the ecosystem. In simple terms, there must be a wetland plant base developed which is large enough to support its partial harvest (by birds and humans) and still leave some organic material for the less obvious but highly important hidden functions noted earlier.

It is imperative that human use of wetlands and wetland products not be all-consuming; other organisms, both macroscopic and microscopic, require a share for their very survival (Maltby 1986). Details of many of the wetland processes noted above are still imperfectly understood. There is a real challenge to science: first to determine the basic means and conditions through which wetlands function, and second to develop sound methods by which this intriguing and important information may be put to use by people the world over to sustain their wetlands while still obtaining clean water, food, and fiber.

### GOVERNMENTAL RESPONSIBILITY

A sound wetlands management policy adopted by governments is a basic step in civil law (Sayer and McNeely 1984; Heritage 1986). There are three levels of government that must consider such action. The first is on the local level, where people are living, where they get their firewood, their thatch, and some part of their food. These are the people who directly live with the constraints and links between wetlands, pollution, drinking water, floods, droughts, birds, wetland plants, and fish. Rational local regulations, developed with local input tempered by what is now known about wetlands, can be of great value in preventing loss of this public resource.

Larger provincial and federal governments are at the second level. In addition to protecting the people and their water and food supplies, the assurance of beauty in the landscape is a national responsibility and is a major reason tourists want to visit a country. Wetlands, in addition to all local concerns, are an integral part of the natural beauty, and thus their preservation and sound management is in the national interest.

At the third level, wetlands are of international concern, a fact recognized by the many nations that are signers of the Ramsar Convention Articles (Lamb 1984; McHugh 1986). Each wetland, especially one of the larger ones, is a unique ecosystem not found elsewhere on the planet. Protection of these resources, in whatever country they may occur, is in the best interests of every other country as well. Rain clouds and water are not respectful of international boundaries. Sound water regimes in one country mean more stable ecosystems for all its neighbors. Our planet is an ecologically integrated whole, a thing of great beauty done in marvelous detail. Cranes, as an example, do not "belong" to either China or the Soviet Union, yet their continued world presence — as hallmarks of beauty, of cultural values, and of naturalists' interest in both these countries — depends upon international cooperation to assure wetland ecosystems at both ends of their migration route. The same can be said of Siberia's and North America's eastern bar-tailed godwits *Limosa lapponica* (Crisp 1986), which winter

in New Zealand, and for a host of other migratory birds the world around.

There will be global impacts on wetlands ecosystems if all migratory birds are eliminated. They eat enormous quantities of insects, invertebrates, and small fish. They distribute plant seeds and vegetative propagules. They recycle phenomenal amounts of nitrogen and potash. Some species directly provide large amounts of human food. Their breeding colony concentrations, their pre-migratory gatherings and their migrations are truly inspiring phenomena

to behold. All of these helpful and inspirational aspects of our beautiful natural world depend first and foremost on proper use and respect for our own local wetlands. Wetland protection is a goal well worth striving for, and one upon which we can build new dimensions of international understanding. As, in accordance with the World Conservation Strategy, we act locally to protect wetland resources, we can take solid comfort in the fact that these actions are good conservation with a cumulative impact on a global scale.

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# NATURE MANAGEMENT: TO BALANCE WILDLIFE AND HUMAN USE

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## ABSTRACT

Management is not the beginning of a process but the final step. Successful management has to start with long careful preparation. After an area is declared a reserve, the best thing is to do nothing and just look around. In management two different processes are recognized: external and internal influences. The external process is related to the influence of the surroundings on the area itself and of the area to its surroundings. External influences will sometimes be so large that it is hardly responsible to carry out any long-term management. The internal process is much more diverse, and gives the manager many possibilities. The ecological process and special preferences for management for certain animals or plants have to be discussed and decided. Preference for breeding cranes can mean that the vegetation has to be actively managed, rather than allowing the vegetation to develop without interference. Subjects such as recreation and a financial balance are also part of this overview. In a good management plan, one will find four different chapters. (1) Map, description, boundaries, country planning in surrounding areas; historical overview, buildings; geological and geomorphological information as far as necessary for management. (2) An inventory of botanical, ornithological, zoological values in different seasons; an inventory of the existing uses and the relation between these uses and the biological habitat; a description about research, both necessary and possible. (3) The real planning of the management, preferably in two parts: long term and short term; short term, for example, might be for five years; this has to be a real summing up of activities for each part of the reserve. (4) Financial and staff needs; real budget for each year and an estimation of income. Along with this document, it might be very useful to develop immediately a system for filing accounts of all the activities and the results in the field. A good system of recorded observations combined with management activities will give the basis for a new short-term management plan and provide information about the ecological processes we try to manage.

## INTRODUCTION

In former times there was a certain balance between nature and man's living pattern. Man used to hunt awhile, then when animals became scarce, he moved a few miles away. If the new area was already occupied, conflict settled the matter of rights. Today, more people require much more careful management, a much more careful adjustment to supply and demand.

In economic theory, resources such as air, water, and nature in general are "free" commodities. One does not have to pay for their use. Nowadays, however, the cost of air and water is high. It is a flaw in economic theory not to take environmental conditions into account.

Economic processes in which nature is deeply involved are different from purely industrial processes. Nature follows a rather slow, complex process; it cannot be hurried. It takes three weeks for a chicken to hatch and nine months for a human being to be born. There are no economic processes imaginable that can shorten these times. The life cycle of certain plants can be shortened and accelerated, but the environmental conditions have to be carefully managed. If not, erosion, exhaustion of the area, and sand storms result: all happen through reckless management and the neglect of environmental conditions of our industrialized, agricultural processes. Millions of hectares are lost all over the world. Instead of trying to win

these areas back, perhaps not for ourselves but for coming generations, we still continue to select the cheap option. Draining, clearing, and reclaiming are the easy ways for short-term profit and the basis for new environmental disasters. Of course, there are also examples of well-managed new reclamations and well-managed clearings. But have we tried to stop the speed of the desertification of large areas all over the world? If we could stop this process or at least slow it down, we would gain more than any new, well-planned drainage or irrigation project could accomplish. But there are absolutely too many areas all over the world that were good green areas in the past and are now useless for people and wildlife.

## FUNCTIONS OF NATURE

Though water and air are basic for human life and can only be kept healthy under natural conditions, people neglect these resources and hope that everything will be all right. To build higher chimneys in order to prevent air pollution near a factory is not a contribution toward wise use of the environment, but only a cheap way to put aside real problems.

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For most biologists, natural diversity is a sign of a healthy environment. It is this diversity we are fighting to maintain and enlarge in limited areas through nature conservation.

Values of nature are related to ethics, aesthetics, and general respect for life. But its products, wild plants for example, can also be used to improve our agricultural plants as long as we do not exterminate these wild ones. The recreational value of nature for mankind is sometimes neglected and sometimes exaggerated. If sea and beach are important for so many people, why are they so polluted that they cannot be used any longer?

Our goal is natural diversity in numbers and in species, and also the courage to fight for this diversity. Large concentrations of geese and cranes might be the crowning glory of years of hard work in conservation and management. We are also fighting for the 204 different species of woodpeckers which all make different demands on their environment. If we lose one of these species, we are not only poorer than before, but we have also made another poor judgment about the use of our own surroundings. Nature management tries to balance all these different challenges.

#### RESERVES AND NATURE PARKS

Nature is no longer the natural environment of our society; nowadays it is no more than one claim in the process of country planning, a claim to be fought for. But natural limits are the reason for the existence of air and water pollution on such a large scale. The limits of using the atmosphere for absorbing our waste are being exceeded and are not in balance with the natural ways of dispersing waste.

Instead of working to solve these problems, we started to create nature reserves: places where nature is more important than human development, places where rare animals and plants can survive, places where people can enjoy the real nature of the past. I think reserves are a right answer, but they are not enough. Through our nature reserves we must fight for more responsible use of our entire environment. It is unacceptable that trees can no longer grow in large parts of Europe; they can no longer tolerate acid rain. We have already lost the lichens, and nobody worries; the sandstone buildings are affected and everyone is surprised; the lakes in northern Europe are suffering from the rain instead of being refreshed.

In general, the aim of setting aside natural areas is to preserve them from certain developments. It always seems to be a defensive, rather than a positive approach. Natural areas are a contribution toward a better environment with living green areas supporting a variety of wildlife and a balanced system which enhances the functioning of nature. Its surrounding area is sometimes completely different. A wetland might be surrounded by desert-like areas, a forest by cornfields, or a reedland by cities and villages. The reserve itself might be protected, but its survival is never guaranteed. We have to control the positive and negative influences of the unnatural surroundings upon our reserve and bring the whole area under management.

There are many ways of protecting an area. In general, it depends upon the political system of the country concerned whether an area has to be bought or can simply be declared a reserve. Sometimes a well-enforced country-planning act can achieve enough protection, but in most countries purchase is the only solution that will insure management and long-term protection. Where ownership is in doubt, it is best to delay a long-term management plan.

Depending upon aims, extent, and national possibilities, we have nature parks, national parks, landscape parks, nature reserves, hunting reserves, botanical reserves, etc. For all these labels there are no internationally, generally accepted definitions. For the contents of this paper, it is enough to realize that there are various types of nature reserves, and we shall only deal with them in a general way. To include more functions within a reserve, or to exclude others, only raises difficulties during the management process. But in principle there will be hardly any difference.

#### MANAGEMENT

If it is clear that an area is to be protected, one has to think precisely about management.

There are many reasons why it is necessary to manage an area. A forester manages his forest because he wants to find the best balance between planting trees and harvesting them, and in the meantime maintain an optimum forest ecosystem. A farmer manages his fields to balance production according to the seasons, the needs of his cattle, the amount of manure, etc. Some farmers now think that only production needs to be managed, and they leave the surrounding environment unprotected from their surplus manure and all the side effects of herbicides and pesticides. But management has to take into account all aspects of an operation, and decisions have to be made about how to resolve conflicts.

Some organizations put management on a completely wrong footing. As soon as an area has been declared a reserve, they start building hides, roads, information centers; they plant trees and make other changes. It is better to do nothing at first, other than try to get acquainted with the area. Provisions to observe the behavior and preferences of the animals are enough. Later, a real plan can be developed on the basis of such information. A negative example is the Tablas de Daimiel in Spain which was declared a national park. A large infrastructure was created, with hides all around for viewing the large numbers of waterfowl living in the area. After a couple of years, the information center was empty and the hides and the park were too. The managers forgot that waterfowl need water, and that it is not possible to have a wetland surrounded by hundreds of hectares of irrigated cornfields.

There are two large groups of influences and activities in a nature reserve:

1. External:
  - a. Influence of the regional environment on the reserve itself
  - b. Influence of the reserve on its surroundings

2. Internal:
  - a. Ecological processes within the area
  - b. Management bias toward some animals
  - c. Bias toward some plants
  - d. Recreation
  - e. Other functions of the area
  - f. Financial balance

From these considerations, a management plan can be developed. Only in the plan can you deal with matters involving people. This paper provides some theory, from which detailed individual management plans can be developed.

First, a more detailed description of various influences is necessary before a management plan can be followed.

## EXTERNAL INFLUENCES

### 1. a. Influences of the regional environment on the reserve

As mentioned earlier, there is a possibility of profound environmental influence from the outside. Planning a nature reserve close to an air-polluting factory is not wise. To prevent the building of such a new plant near your reserve is commendable. It is wise to plant trees around the factory, but that action does not make a nature reserve, nor will the area ever become one. Reserves have a completely different function. They should not be surrounded by polluting factories, farms and cities, although if there is no choice, it is always better to accept such an area than to have nothing. The reserve in the center of the harbor in Tokyo, Japan, is not easy to manage. Completely surrounded by pollution, it is restricted in its possibilities, but it is also an excellent educational project, a victory for conservation, and a living warning system with real birds giving the signals. One should not try, however, to develop biological processes sensitive to air pollution.

Indirect environmental influences are even more difficult to comprehend: pesticides found at the South Pole, or acid rain in Scandinavia from factories over 1,000 km away. Such processes cannot be controlled in a single nature reserve. We can only use the reserves to show the disastrous influence of these processes and to fight against the irresponsible use of pesticides and lax industrial procedures.

In general, small nature reserves will suffer greatly because of their surroundings, but again there are conceivably several reasons why establishment of such reserves is justified. Only their possibilities are restricted.

### 1. b. Influence of the Reserve on its Surroundings

The nature reserve will sometimes have an influence on its surroundings. Sometimes the chief influence is educational, promoting the acceptance of reserves. A rabbit coming from the grounds of a neighbor whom you do not like is always unwelcome. It is better to become good friends with your neighbor than to start a discussion as to whether the rabbit really causes damage.

But again it is the scale of your reserve that is really important. A small area does not disturb, and cannot contribute, much; but large areas will have an impact. Certain animals and plants will not stay in the reserve and will penetrate the surrounding area. Such behavior can be taken into account in the management plan itself. One of the considerations in the management of an area must be that its surroundings will not suffer inordinately. If it is a reserve for elephants, it is not acceptable for large groups to destroy the agricultural areas outside the reserve each night. The reserve is probably too small. A certain degree of influence, however, should be acceptable.

It is much more difficult to measure beneficial effects. Owls will eat mice in the surrounding fields, and the reserve might provide some beneficial influence in the micro climatological conditions. Although hedges are seldom nature reserves, one sees the difference between agricultural areas with hedges and those without. Partridges, pheasants, birds of prey, and songbirds define the richness of an agricultural area intersected by hedges, and they are all absent from areas with monocultures. Quality is never easy to measure, but loss of quality is easy to see and difficult to repair.

External influences should be considered very carefully. Following study, the boundaries of an area may need to be changed.

## INTERNAL INFLUENCES

### 2. a. The Ecological Process

It will be difficult to speak in general terms about the internal processes of the area. One of the most important questions will concern the type of vegetation and the degree of its succession. To answer such questions, botanical knowledge is necessary. Common sense is also important, as basic alternatives have to be considered. If the vegetation has reached its climax (e.g., forests, sea shore, dunes, or lakes), a management process will be completely different from a situation in which the vegetation has yet to pass through several stages (e.g., young forests, shallow water, moors grazed by sheep, or meadows).

I am not suggesting that the first types are stable and the second dynamic. They are all dynamic botanical processes that require sound judgment as to their use. A forest may be a climax situation, botanically speaking, but fire, storm, and age will always change the area. Forests of different ages, including open areas, will often be present in a natural situation. The same will be true near a sea shore where the salt water determines a certain type of low vegetation.

In situations where the vegetation itself is still undergoing change, sometimes caused by human activities, management becomes another factor for change. Much nature management in the world attempts to slow down the natural ecological processes in favor of a certain type of ecosystem that would be rarer under natural circumstances. Perhaps after changing so much in our environment, it is necessary that we do a bit more work on our reserves.

As a result of diking rivers, open areas that regularly flood no longer exist within parts of Europe. We created inland meadows for our cattle. Wintering geese also use such meadows. Geese can only use such meadows if the grass is low in winter. If we create such areas, we have to reintroduce flooding, which will be difficult to do in many situations, or we have to maintain this special type of landscape by grazing or mowing. We have to do exactly what the former users did who created this kind of area, but our aim is different. It is always possible to look for a combination of these aims.

These remarks can only be made by an author who has lived for a long time in a small country. Of course there are many situations in which marshes and meadows do exist in a natural way, sometimes with human use, and after a thousand years they will remain the same. Endless marshes can be a complete system of endless water reserves and, therefore, all vegetation processes between water and land will always be present, including the natural variety. There are too many examples, however, of unexpected and unpredicted side effects of activities near large nature areas. Care must be exercised. The vast marshes of the Everglades in Florida, U.S.A., are severely affected by an altered water regime in this region and are artificially managed so that the area remains open and with little forest penetration. Former marshes that have been changed into dry, quite uninteresting forests through lack of water and proper management are legion. Wetlands all over the world suffer from changes in their surroundings, and frequently management efforts are necessary to remove these influences.

In forests we are generally concerned with intense human use that makes reserves difficult to manage. It is hard to predict whether a man-made forest will ever grow into a natural forest again, with the same variety of tree species as there was before human interference. Even if such processes were to take hundreds of years, it is important to set aside areas where they can take place. Nature management is not something for our generation, but for the generations to come.

In small areas one must decide upon one among a number of choices for the ecological processes. After a choice is made, it should be adhered to: a new system with each new manager is disastrous. Once the choice has been made to allow the ecological process to develop undisturbed, the same policy must be followed for the next hundred years, unless significant influences from the outside prove the decision unviable. Short-term results should not be demanded; let nature take its time.

Large areas are perhaps easier to manage after a decision is made, but the decision is extremely important for the future of the area. Politically-minded people who have no knowledge of ecological processes should never be involved in the management practice, even though they are involved in the establishment of the reserve. Nothing is more harmful to the future of a reserve than the intervention of influential people in internal matters. After the establishment of a reserve, management is a technical, not a political, process.

## 2. b. Special Preference Toward Some Animals

Since nature offers limited possibilities, it is difficult to develop complete, natural ecosystems in all reserves. There will be special reserves for breeding cranes, for tigers, and perhaps for dragonflies. In theory it is not easy to defend such preferences, but in practice they are necessary because of the limited area of reserves and the sometimes conflicting conditions required by different species. In a huge marsh, a crane will always find a square meter needed for its nest. But this chance will be reduced practically to zero if the marsh is very small and natural succession is to continue. If the marsh is especially established as a reserve for breeding cranes, one has to manage water and vegetation. Cranes will respond by breeding in the well-managed site. But in a small area one should not bring too many conflicting interests together. Cranes, wild boars, human visitors, undisturbed botanical processes, and harvesting of sphagnum can all be combined on 10,000 ha but not on 5 ha. If you prefer to preserve a traditional crane-breeding territory on your 5 ha site, you must exclude all other activities. You must carry out a restricted management plan or give up the cranes. One should not ask the impossible of the small site.

The greatest satisfaction derived from a well-executed management plan will always be the spontaneous establishment of new species or the enlargement of an existing colony. This is a human perspective, however, and not always the best ecological one. "More" is the human assessment of success; ecologically, just a balanced minimum is much more attractive. A huge colony of herring gulls *Larus argentatus* is a challenge to the manager, but perhaps not the best size colony within which vegetation and other seabirds can build up a balanced community. Management is not for just many of one species, but is for a balanced system which can survive by itself.

Bias toward certain species, however, is sometimes necessary. Some animals have evolved into such bizarre specialists that they can never survive in our society. One of the challenges for nature conservation is to find solutions for these specialists and to create an environment in which the remaining variety of species can survive. Some species pose many problems. If giant pandas *Ailuropoda melanoleuca* ate grass instead of bamboo, or if black-necked cranes *Grus nigricollis* did not breed only in marshes 4,000 m high in the mountains, management would be much easier. The challenge for the politician is to create opportunities for the variety of ecological requirements and, for the manager, to bring them to fruition.

## 2. c. Botanical Preferences

An area with rare plants or a special type of vegetation may be especially managed in accordance with biological preferences. Most types of vegetation, however, will develop naturally if the circumstances conform to the conditions required by these communities. Many of the North European heaths evolved several hundreds of years ago after the land was deforested. Keeping these areas open, with their own botanical and zoological community, is one

of the aims of nature conservation in these countries. Although we now know how to manage such areas, acid rain and general air pollution destroy this process; it is unlikely that we can maintain the heather community in these countries.

Orchids are also plants for which people wish to give a certain priority. Some species of orchids grow together in dense communities, but a nature reserve is not a flower garden and should not be managed as if it were. In general, it is best to develop and manage the whole community in which orchids appear and disappear according to ecological laws.

Preference for certain plants is sometimes easily combined with the desire to harvest and to slow down the natural succession. Reed *Phragmites communis* is a good example. Reed is an early pioneer in waterland margins. It grows in water 2-3 m deep and can grow for many years under rather dry conditions. If it is possible to control the growth of reed (by harvesting or burning), the marsh will keep its original character for centuries. If this harvesting can be combined with a sound financial approach, it will be a successful management tool. If commercialization of the reed harvest becomes the chief aim, however, the activity cannot be accepted in a nature reserve. Commercial harvesting must be part of the preconceived management plan. But if protection is dependent upon the commercial harvest, results will never be acceptable and will become a source of many conflicts. It is better not to pretend to have a nature reserve if reed harvesting is the main aim of the area.

Here again, some preference for certain communities or species is acceptable within certain limits. Once a choice is made, it should be supported. The area will be ruined if each well-meant management idea is immediately carried out. If processes have to be readjusted, this should be done carefully and step by step. If grazing an area is no longer acceptable, it is not wise to stop it all at once. If grazing has occurred for many centuries, it does not matter if it goes on for a couple of years more. First you have to know what grazing is doing, biologically speaking, and then make the appropriate decisions. Finding the balance between acceptance, biological desirability, and political wisdom will challenge the manager.

#### 2. d. Recreation, Interpretation, and Education

Even more wisdom will be needed to tackle problems arising from people's preferences for the reserve.

Never tell people that the nature reserve is paid for with their taxes and therefore it should be managed as they wish. For then people will think that a nature reserve is a sort of cheap television, where one can watch tigers eating deer, see mating animals all over the place, and make other thrilling observations! In general, nature reserves are rather dull areas, but with a certain beauty. Of course it is fitting to show people the results of conservation. They should watch from the outside, realizing that beyond the hills it is even more beautiful as long as it is not touched. It is impossible to show a thousand people an eagle's nest up close. Nature has its own rights, and we should not let

an environment be overrun by people who do not know what to see.

I have intentionally chosen a rather negative approach to recreation. There are too many instances in which nature is shown to the public, then nature disappears, then the people. There are few instances in which large numbers of tourists can enjoy wildlife. Some of the African parks are exceptions. Most of the large animals in the world are so rare, so afraid of people, or so nocturnal that it is difficult to see them. Seals and many bird species are also exceptions. In particular, birds breeding in colonies are easier objectives than the solitary breeding crane. The fact that it is impossible to show more than ten people the nest of a particular crane does not make this bird less important than a white stork which has its nest on a village telephone pole.

If people do not have the "right" to disturb nature inside (or outside) reserves and parks, what possibilities exist for exposing them to life inside the reserves? The possibilities are boundless, even within the limits of responsible use. To open an area to various recreational opportunities is extremely important for its acceptance as a reserve and for conservation in general. Several issues, however, must be considered, including policies toward cars, restaurants, overnight facilities, hides, guided tours, information centers, and free entrance versus a fee.

As a general rule, recreational use should occur along existing paths so that adequate undisturbed areas remain for wildlife. A recreational management plan will be necessary after one has formulated the ecological aims. Large inaccessible areas will contribute greatly toward the purposes of the reserve and the imagination of the public. Knowledge of the area and the different processes involved is necessary before visitors can be shown bird life. Through a reed-tunnel, limited numbers of people can be brought into the center of a cormorant colony, an experience no one will ever forget. Local conditions enabled managers to carry out such a project. For most colonies, however, too much of the environment would have to be changed to achieve this kind of result: the birds would probably abandon the area before the first visitors could watch them closely. It is much easier to give people an impression of the area. Vegetation and landscape are easy to show, but because of television people expect too much from a simple visit.

It is dangerous to start special attractions for the public too soon. It is much better for the reserve to establish itself over a period of many years, and to learn where the attractions are and how to manage them for public benefit. New roads should not be made, but sometimes existing ones must be reevaluated. Recreation must be limited so that natural processes can unfold with as little disturbance as possible.

Few examples exist of well-organized national parks in which large numbers of people can enjoy themselves. In general, these parks have geological formations like caves, waterfalls, etc. Natural beauty seems to be more easily managed than living nature. For example, it is easier to show people a sunset than the flight of a nightjar, which happens at the same time. The distance of the sunset is

accepted; the nightjar is always too far away.

In general, cars should not be admitted to reserves and parks. Although a few animals are less afraid of cars than of people on foot, the speed of cars is not compatible with the aims of the area. Transport by silent boats through certain areas is ideal (but here, too, some water areas should not be visited).

All special facilities, such as restaurants and overnight places, should be located near, but not inside, the park, except of course where a park can develop a special use for "trekking" with overnight facilities in hides. Even an attractive hotel inside a nature park will cause disturbance and other problems; if there is a choice between developing one inside or outside the park, I would always suggest placing it outside.

It is important to use reserves and parks for education and interpretation, as long as people are left free to enjoy themselves in their own way.

A large park needs a staff of officers who can provide guided tours, interpretative routes, information centers, and school programs. These are essential for the area, both for long-term nature conservation and for best use of the amenities within the area. If properly managed, recreational use is desirable. My aim here is to stress management of recreational use combined with conservation of resources.

#### 2. e. Other Functions

As already mentioned, it is possible to combine several functions within a nature reserve.

To take reeds again: as reed, *Scirpus*, grass, and even trees afford valuable products, it is interesting to see whether there is some possibility of using these products, not as a new demand on the area, but in support of the proposed, most desirable management.

As we have seen, there are many occasions when natural processes have to slow down. This means harvesting. A profit on the harvest is always welcome.

A profit from hunting is also welcome. If the regulation of certain species is desirable as a result of the aims of the reserve, there is nothing wrong with allowing organized hunters to help achieve this goal. But if hunting becomes an aim in itself, it is better not to organize such an activity within the reserve.

Raising pheasants for shooting should not occur in a reserve. There are enough places outside the reserves, in forest and agricultural areas, where such activities can take place. Politicians usually favor combining activities, such as hunting or flying of model airplanes, in nature reserves. These activities do not support the aims of the reserve and therefore cannot be justified.

A nature reserve is not a buffer between a polluting factory and a city. It needs a buffer for its own purposes. Country planning should show careful judgment, because long-term, well-managed processes are very difficult to replace or relocate.

#### 2. f. Financial Aspects

Nothing is obtained without money, even in nature. In

each political system, the means of establishing the reserve will differ. The system itself will determine whether people have free access to a protected area, or whether the manager can demand a fee. A fee creates expectations; people will happily pay to see something in the wild. A well-equipped information center, guided tours, information staff: people are willing to pay for such services, but they are reluctant to pay to enter an area without the expectation of seeing something alive. Money cannot be charged for a sunset.

Sometimes national park managers make poor financial decisions. Let us imagine a park (60,000 ha) with a small staff of 10 people and subsidized by the national government. Each year over a million visitors come to the park to enjoy nature. The ministry responsible for national parks must pay these few staff each year and also buy supplies for an information center. Visitors' fees do not go to the national park or to the appropriate ministry, but rather to the ministry of tourism which in the name of the park organizes visits by tourists. Such an approach is wrong. It takes a single strong hand to manage and organize a park or reserve. This "hand" does not deal only with plants and birds and enthusiastic bird lovers, but it manages the entire operation, trying to maintain a financial balance. Excluding the costs of once-only purchases, some areas can be managed easily with an annual financial balance, especially in larger areas where a nearby hotel pays annual fee, or where several facilities exist, and where some products can be sold. Such management demands sharp financial acumen together with sound knowledge of the possibilities of the area. If a bus company is not willing to pay a fee for the privilege of bringing thousands of people to the reserve, another company should be found.

Many small reserves, with limited aims and recreational possibilities, are expensive to maintain. This cannot be helped. Local politics, special expenses, or special ecological processes sometimes in a fenced-off area, can make it necessary to collect fees to support the aims of such an area. Tolls should be collected on roads leading through it.

Financial problems should be taken in stride. Nature offers a unique experience if it is well-managed. As nature reserves are developed, the public, with ever more leisure time, will use them.

This approach is rather "western." In many less-developed countries, such an approach could be more emphasized. Fish farms and certain agricultural activities, as long as they are in accordance with the aims of the reserve, can be acceptable. In providing firewood, local fishing, hunting, and guided tours, a nature reserve is a living system. Well-managed, it will offer attractions for thousands of years.

Nature reserves will never yield high returns on investment. For those who have lost confidence in the Bank of England, a nature reserve is no alternative!

#### THE MANAGEMENT PLAN

Once the aims of a protected area are agreed upon, a management plan can be drawn up. To continue to discuss aims at this stage will cause frustration.



If the area is safe, if people know what they want, and if information about the area is available, then the plan should be developed without hesitation. There are four parts in a management plan:

#### Basic Information (Mainly A-biotic)

Many factors must be taken into account. A map should be developed, preferably one on which it is possible to note the various components of management and recreation. Depending upon the scale of the area, sometimes 1:25,000 and 1:5,000 maps are a necessity. For special projects within the boundaries, large-scale maps are useful.

The boundaries of an area, in place already or planned for the future, must be defined not only on maps but also in the field. Since boundary disputes are common, they should be anticipated in the management process. In many countries there is a country-planning system, where future plans which might have an influence on the reserve can be taken into account. It is also important to gain acceptance for the area itself as well as for a buffer around it as soon as possible. It is helpful to persuade local authorities to learn about the plan by being involved in the process.

A description of the area, including its history, must be provided. In many cases there will be a local "expert" who has lived all his life near the area and can give a lot of basic information. If there are buildings, it is wise to make a decision about their disposition as soon as possible. Historical buildings require maintenance, but they will also be a drawing card for the future. Vulnerable ecological processes should not be developed close to such sites. Useless buildings, or buildings which might give more problems than pleasure, should be demolished as quickly as possible before other interests arise. It is always better to have buildings outside the area rather than inside. Even a warden who lives inside the area will soon need electricity, a school bus, and water, all disturbances which are better left outside.

Geological and geomorphological maps and descriptions are useful. From these descriptions one can learn a great deal about hydrological processes and come to understand vegetation differences in the field that are related to soil structure and other geomorphological data. It is not necessary, however, to wait until these data are available. With some simple aids, such as a borer and altimeter, it is possible to get started.

#### The Ecological Inventory (Biotic Information)

It is important to have available an inventory of biological processes and data relating to plants and animals, preferably based on several years' observation.

Of course it is impossible to know everything before beginning management of an area, but some key information is necessary. For mammals, one should know about rare species, large herds, where the mammals stay, diurnal or nocturnal habits, etc.

For birds, locate colonies, large birds of prey, concentrations of birds during winter or migration, rare species with special needs, etc.

Management must consider more than just mammals and birds, but one is restricted. Additional information about reptiles, amphibians, fish, and insects are most welcome.

A vegetation map is essential for good management. Maps again can be very rough or very detailed. Forest-marsh-water doesn't give much information, but a subdivision into different types of forest, different ages, different management in the past gives much more information. More detailed vegetation maps of certain parts of the area are important, for example where one wants to follow the succession. Detailed knowledge about plants, vegetation, and their succession is necessary to develop a good inventory.

During the process of gathering these types of information, ideas about management are developed. It is essential, therefore, that those who are responsible for management are involved in at least part of the process. It is not necessary to know all the birds or all the plants, but a certain knowledge of processes is essential.

If the area under consideration is a new lake in bare surroundings, the inventory will be short; much more attention will need to be given to the planning of new activities. If the new area is a complex thousands of years old, however, and contains marshes, meadows and forests, the inventory will be proportionately long; one shouldn't start many activities soon. The different processes do not have to be described in great detail. Their description constitutes only a kind of enumeration of possibilities and necessities which have to be taken into account.

It is also important to describe the existing use of certain areas — agriculture, hunting, cattle grazing, etc. After describing these uses, record any influences on vegetation or other animals. If it is clear that overgrazing by cattle takes place, this problem has to be resolved before the establishment of the reserve. In some situations cattle contribute greatly toward the biological diversity of the reserve. But could this role instead fall to native mammals? Any processes involved, as well as the numbers of cattle, must be recorded precisely.

Another important matter needs to be considered — research. Biological research, and also agricultural, sociological, and economic research, depend entirely upon the size and structure of the area and on what kind of research is acceptable. Small reserves are not very attractive for basic research, but it is interesting to find out how they contribute toward the value of the surroundings in which one lives. As for biological research, two different types are relevant.

Fundamental research or development of instructional materials for schools and universities are always possible. The unique aims of the reserve, however, are more important than the research possibilities it offers. If there is a vulnerable bird colony in the reserve, any research program must show an awareness of its presence. That colony must be preserved by the manager. Thus research is only possible when the reserve itself is the primary concern.

The other type of research is directly related to management itself: basic work such as making inventories, ringing and measuring birds, and also experiments to ascertain the best possible management proposal. A wide range of

activities is important to planning the future of the area, if the reserve is to be well managed. No small portion of a project should lead immediately to specific management proposals. All research results have to be integrated with other data into an overall management plan.

If a researcher looks into the spider fauna of an area, he may find that many vulnerable spiders are lost during mowing time. His first advice will be: no mowing. But to refrain from mowing might not be good for the spiders, since a mown, regularly disturbed area is their preferred habitat. Also, mowing is related to management of the vegetation and the breeding of some birds that prefer short vegetation. A solution might be to mow a little earlier in the season and hope enough spiders survive the disturbance.

While it is worthwhile to understand all the processes in an area, each new piece of knowledge does not necessarily lead toward new and revolutionary management practices.

### Management Plan

All these ideas, thoughts, inventories, and considerations contribute to the ultimate task: the creation of a management plan. This plan will be a description of activities for the area as a whole, and for the various parts, together with the proposed outcome.

First, a long-term plan has been developed which provides a prospectus for the first 10-50 years. It deals in detail with borders, environmental, zoological and botanical aspects are noted, and a measurement scheme is constructed.

Sometimes it is wise to present such a plan to the local community or to discuss it with the local authorities in order to involve them in the planning process and to make certain that the country planning authority in the region is informed about proposed activities. Presenting a plan to a wide audience has advantages.

Second, the short-term management plan is developed, a document intended only for internal use. For the area as a whole, and for each clearly identifiable part of the reserve, it is essential to mention all necessary activities to be undertaken and during what time of the year.

Two examples will suffice:

"C15" Heron colony. No access from March-July, except one day (good weather) in June for general count of nests and juveniles. (University's ornithological department and "X" involved). In November, planting of oak trees in eastern part.

"C16" Young forest timber. Possible site for overspill of colony in 10 years' time, but trees now too young for herons. Botanical survey in July. Planting oak trees at western edge (November).

Additional information about the C15 area will appear in another section, including area in hectares, water level, botany, ornithology, number of herons in different years, possible disasters caused by storm or fire.

Plans for one to five years are a prerequisite of good management. Sometimes five-year plans are sufficient, but in complicated situations where a variety of activities take place, it is better to have annual plans.

It is not advisable to divide information on activities into different chapters. Activities in "C15" have to be mentioned all together under C15, as it is impossible to develop a daily or monthly work schedule if the whole plan has to be read each time. Even if there are separate chapters for special subjects, such as recreation, it is necessary also to transcribe the actual activities under the area numbers.

If a picnic area in "B6" is to be developed next year, this information will be under B6; and there is still time to develop this plan in detail. This year the road from B1-B7 has to be repaired. A management plan is an enumeration of activities, but in this context "doing nothing" is also an activity. The well-planned non-activity is just as important as any undertaking.

Working from the general overview toward the details will prevent mistakes. To list all kinds of work in a certain area is far easier than to create a long-term management plan in which processes are described and integrated. But a short-term management plan without the support of a long-term plan will nearly always fail.

### Finances and Personnel: Result or Limiting Factor

Few plans are developed for which staff and money are immediately available to the extent one would desire. Of course plans should be realistic, always taking into account their feasibility. But feasibility is not a limiting factor, since a good management plan should be "sold" to those who made the decision to create a reserve.

Management activities are necessary and will cost money. Sometimes, it is more economical to have one's own personnel to carry them out; sometimes, it is cheaper and better to involve local contractors. Each area and each country has its own approach.

For basic activities such as carrying out inventories, guarding, interpreting, distributing information and the like, management needs its own personnel. In general, small nature reserves require relatively more personnel than large ones. The types of work will determine how many people are needed.

Thus finances and numbers of personnel are the result of the plan. If it is necessary to readjust these figures, then the management plan itself must be readjusted.

At this time, it must also be decided whether local people are to carry out certain management activities, such as cutting reed, grazing, guiding tours, wood-cutting, hunting, and fishing. If it is possible to reach favorable agreements for enclosing areas and creating a sound financial basis for management, the aims of the reserve will be furthered. But many examples illustrate a promising beginning after which local economic activities soon threatened the reserve!

Title of ownership and purpose of the area must be made clear to prevent usurpation of a reserve that prospers.

### EVALUATION REPORTS

Regular reports of activities and observations should be kept. Using the same maps and the same compartment numbers, as shown in the management plan, makes record

keeping easier. Information thus preserved is available at once for a new plan.

Reports relating to the management of the area should not contain biological observations alone, but should also give an overview of the management activities. For large areas, an annual report will be helpful, but for smaller areas simple data-gathering will be enough.

In general, it will be impossible to collect data on all biological phenomena which are of interest in the area. But a selection can be made of 10-20 species of animals and plants. Not only rare ones, but also one or two samples of common species will show how such a population changes in relation to management activities. Cranes, certain birds of prey, colony breeders, woodpeckers: all are key species for management reports. Results should contribute toward the management plan itself, but basic management directions should not be changed too quickly.

A computer is not necessary in collecting or processing the data. A computer may encourage the collecting of useless data even where no good program exists. The initial collection of data can easily be done with a simple filing system from which systematic lists can be developed. Later, a computer could be used to advantage.

#### CLOSING REMARKS

This overview of management is not a manual for a plan. It may be of assistance in thinking about such plans without fear. If help is needed in a country where no specialized information is available in a particular field, visiting a school or a local manager in another country may afford experienced counsel. Inviting specialists to one's own area is another possibility, but is not always feasible. Specialists can offer ideas and general advice, but only the persons living in an area have knowledge enough to draft a plan.



## BIRD CASUALTIES FROM COLLISIONS WITH A 500 KV TRANSMISSION LINE IN SOUTHWESTERN VICTORIA, AUSTRALIA

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### ABSTRACT

A survey was undertaken of bird casualties from collisions with a 500 kv transmission line in Western Victoria, Australia where it crossed farmland with a mosaic of wetlands. The survey was done for four consecutive days at four weekly intervals from August 1985 to August 1986 and included a period of time when the transmission line was not energized. The remains of a total of 130 individuals of 20 species and two other genera were found. Black swan *Cygnus atratus* and straw-necked ibis *Threskiornis spinicollis* comprised 35% and 29% respectively of all birds found. Most species were water birds, some being nocturnal. Remains were found in every survey period and recently killed birds were found in most months. Additional species were found during random inspections at other sites along the same transmission line including two brolgas *Grus rubicundus*. It is probable that casualties were higher; scavengers and predators would have removed birds and dense vegetation would have obscured others. Suggestions are made as to the siting of transmission lines in relation to wetlands and breeding colonies.

### INTRODUCTION

The incidence of avian collisions with power transmission lines has been documented elsewhere in the world (McKenna & Allard 1976; Willard 1977; McNeil et al. 1985; Olenдорff and Lehman 1986). But most have involved lines near to, or crossing, large expanses of water. No published information is available for Australian conditions. Anecdotal evidence is available, however, particularly the incidence of brolgas striking power lines (D.M. White pers. comm.; authors' personal observations).

The southeastern area of Australia is the most densely populated area in the nation, resulting in larger numbers of public facilities and associated industrial development. In order to provide a reliable, secure and more economic electricity supply, a power grid is proposed to link up three states, New South Wales, Victoria, and South Australia. There is an existing link between Victoria and New South Wales (Figure 1, from Kinhill Stearns 1986).

An existing 500 kv transmission line runs through Western Victoria, terminating at the Alcoa Aluminum Smelter at Portland. This line crosses an extensive wetland area and effectively bisects the main brolga breeding areas in southeastern Australia. This region also supports colonial nesting species (see Figure 2) such as straw-necked ibis, sacred ibis *Threskiornis aethiopicus*, Australian pelican *Pelecanus conspicillatus*, royal spoonbill *Platalea regia* and cormorants *Phalacrocorax* spp. (Cowling and Lowe 1981; Arnol et al. 1984; Blakers et al. 1984; authors' personal observations).



Figure 1. Three state interconnection.

In order to achieve the three-state link across Western Victoria, the relevant state authorities (State Electricity Commission of Victoria [SECV] and the Electricity Trust of South Australia [ETSA] propose to run a 275 kv transmission line between a terminal station near Heywood, Victoria to an area north of Mt. Gambier in South Australia. There are six alternative route options (Figure 3, from SECV & ETSA 1986). The six alternative routes were rated by us in wildlife values using data obtained from previous wildlife surveys carried out in southwestern Victoria (W.B. Emison, unpublished data). Three ratings — high, medium and low — were allocated on the basis of species diversity, species significance, and species known to be at risk from collisions with transmission lines.

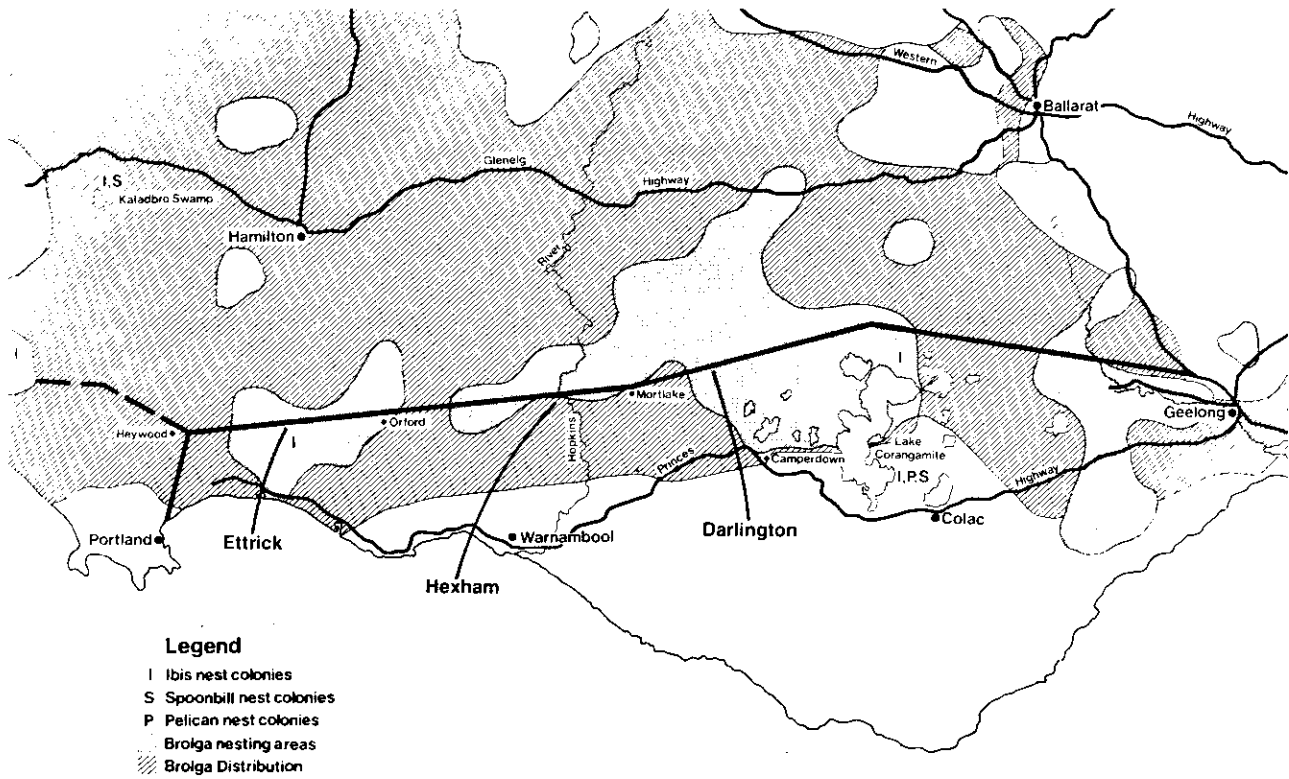


Figure 2. Route of existing 500-kv transmission line in western Victoria, with nest areas of cranes and colonial water birds.

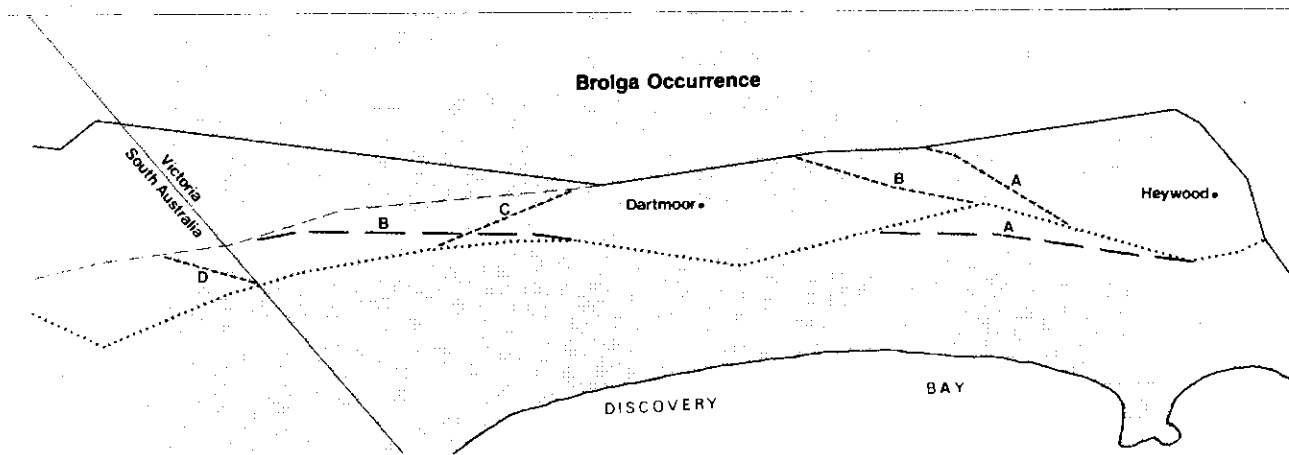


Figure 3. Proposed 275 kv transmission line Victoria to South Australia.

To assist in the preparation of an Environmental Effects Statement (EES), we undertook a survey of a 6 km transect of the existing 500 kv line, with geographic conditions similar to the proposed 275 kv line, to obtain data on bird mortalities.

The survey on the existing 500 kv line was undertaken

from August 1985 to August 1986 and included a period from August 1985 to April 1986 when the line was not energized, and May to August 1986 when the line was energized. The line consists of six groups, each of four main conductors, and two single-cable lightning conductors or earth wires above (Figure 4).

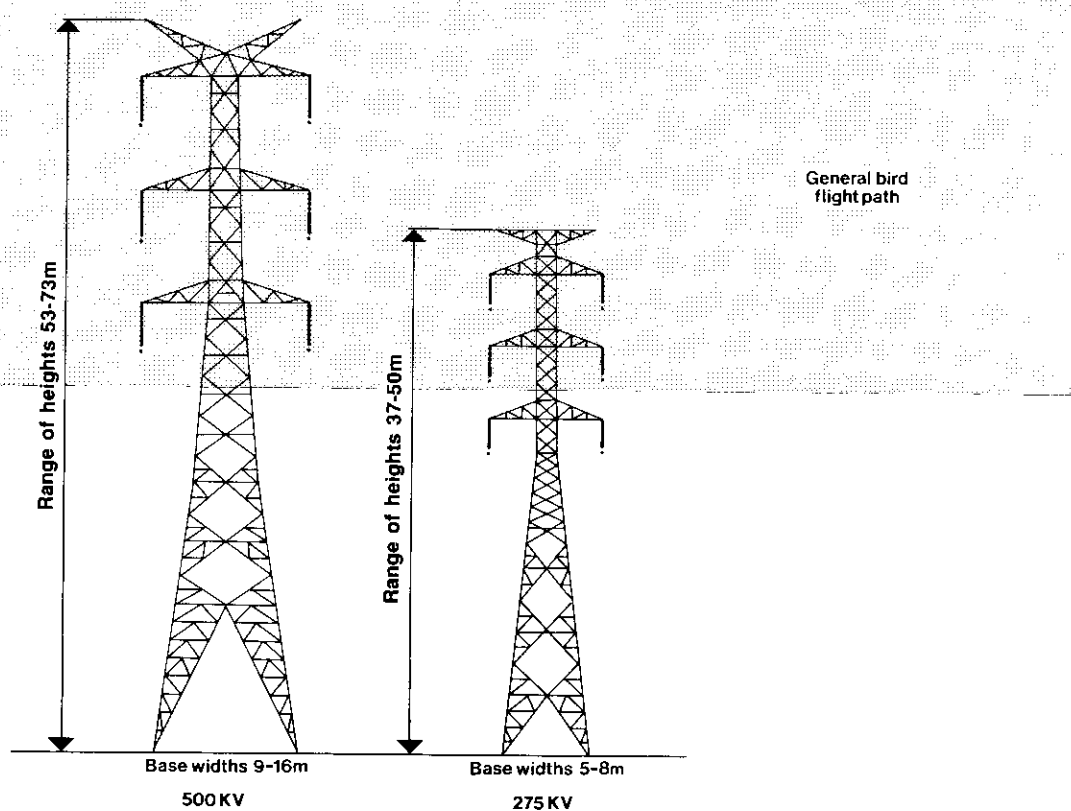


Figure 4. Line structures 500 kv and 275 kv.

## METHOD

Originally two study sites were selected. One site was at Darlington, a cropping/grazing area on basalt plains containing swamps and lakes, where a brolga collision had been recorded; the transmission line also cuts at right angles to the Mount Emu Creek at this site. The other site was at Orford, a grazing area containing a mosaic of small wetlands or swamps (each < 3 ha) and remnant eucalypt woodland. The bulk of the survey, however, was restricted to the Orford area (Figure 1). The nearest comparable weather station is at Heywood, 40 km west of Orford, which has an annual rainfall of 837 mm with 547 mm (65%) falling from May to October.

The survey was conducted over 12 months, on four consecutive days once every four weeks as soon after daylight as practicable. Two transects were walked, one under the transmission line, and a parallel control approximately 500 m north of the transmission line.

Two people walked a zigzag course in opposite directions under the line, commencing from about the middle of the

transect. The 6 km transect included the area extending out approximately 50 m on either side of the line. Binoculars were used to scan the area for dead and injured birds and to assist in identification of live birds whose presence and movements were also recorded. All carcasses and remains were collected and removed in order to prevent duplication. Weather conditions at the time (wind, temperature, rain, fog, and cloud) were recorded to determine whether they had any influence on collisions. The condition of the swamps and pastures was also noted. The survey was completed by returning to the start point via the control transect. On alternate days the control was surveyed first. The surveyors also alternated on the half sections walked in order to remove bias. The condition of dead birds was noted (fresh, old), and the occurrence of predators in the area was recorded. Specimens that we could not accurately identify were sent to the National Museum of Victoria for confirmation.

Random spot checks at other locations were also made under the transmission line to indicate the spread of collisions. Other instances of collisions were also reported to us (Richard Weatherly pers. comm.).

## OBSERVATIONS AND RESULTS

## Dead Birds and Bird Movements at Orford

A total of 126 individuals of 20 species was collected under the transmission line (Table 1). The remains of four additional individuals that could not be accurately identified were also collected. In addition a further 10 individuals of six species were noted at this site prior to the survey. These included four straw-necked ibis, two starlings, one sacred ibis, one Pacific black duck *Anas superciliosa*, one black swan and one Australian magpie.

Only three dead birds were found on the control transect, two Australian magpies and one little raven *Corvus mellori*.

Most identified species (14) were water birds, the others being birds of grassland and woodland.

A total of 75 bird species was recorded alive during the survey. Thirty-two of these species were seen flying through the transmission lines or earth wires.

Five species found dead under the transmission line were not recorded live during the survey. These were the blue-billed duck, buff-banded rail, marsh crake, coot and feral pigeon. The purple swamphen was recorded on only three occasions, yet eight dead birds were found. The black swan, which comprised about 35% of dead birds found (45 of 130), totaled less than 2% of live birds seen (135 of 12,763).

We were unable to study bird movements at night. Most of the birds found under the transmission line, however, are known to fly at night or in twilight conditions. The raven, feral pigeon and skylark are not known to do so.

The reactions of birds to the transmission line were variable. Factors assumed to influence their reactions included light and wind conditions and whether they were flying singly or in small or large flocks. Large flocks of birds were more likely to be disrupted by the transmission line than were small flocks or single birds. This was particularly noticeable with the ibises where flocks were "broken up" when attempting to cross the line. Some birds veered away from the line rather than cross it.

Strong winds blew some of the smaller species through the area of the lines and, on one occasion in September 1985, a group of four yellow-billed spoonbills *Platalea flavipes* which was flying downwind was unable to gain enough height to fly over the lines even after two attempts at flying back into the wind to do so. They eventually chose to land rather than cross through the lines. Weather conditions at the time were rain squalls with wind strength Force 4 on the Beaufort Scale.

Ibis flocks in the early morning and in fog also appeared to have difficulty in detecting the line. Deaths were still recorded after the line became energized.

Species			(Pasture Long)		(Swamp Dry)		(Pasture Short)				July		Totals	
	Aug 85	Sept 85	Oct 85	Nov 85	Dec 85	Jan 86 <sup>a</sup>	Feb 86	Mar 86	Apr 86	May 86 <sup>b</sup>	June 86 <sup>b</sup>	July 86 <sup>b</sup>		Aug 86 <sup>b</sup>
<i>Podiceps poliocephalus</i>													1F	1
<i>Ardea novaehollandiae</i>		1												1
<i>Botaurus poiciloptilus</i>					1									1
<i>Threskiornis aethiopica</i>		2										1	1F	4
<i>Threskiornis spinicollis</i>	10	5	5(F1)	1F	2		3(F1)	1	4	3		2(F1)	2	38
<i>Cygnus atratus</i>	9(F2)	15	5	2	1	1F	1	2(F1)	3	1	1F	3F	1	45
<i>Tadorna tadornoides</i>	1	1												2
<i>Chenonetta jubata</i>													1F	1
<i>Oxyura australis</i>									1F					1
<i>Coturnix novaeseelandiae</i>									1F					1
<i>Rallus phillippensis</i>													1F	1
<i>Porzana pusilla</i>							2							2
<i>Porzana tabuensis</i>							1							1
<i>Porphyrio porphyrio</i>		1F		1		2F	2F	1	1					8
<i>Fulica atra</i>													1F	1
<i>Columba livia</i>								1						1
<i>Alauda arvensis</i>														1
<i>Anthus novaeseelandiae</i>			1			1F								2
<i>Sturnus vulgaris</i>		1						1		2	1	1	2F	8
<i>Gymnoprhina tibicen</i>			1	2	1			1					1F	6
Ardeiformes or Anseriformes								1						1
<i>Coturnix</i> spp.										1				1
<i>Corvus</i> spp.	1													1
		1												1
	24	24	12	6	5	4	9	8	10	7	2	7	11	130

Note: During September 1985 a local farmer removed three straw-necked ibis carcasses prior to survey being done.

<sup>a</sup> Transect surveyed 2 days only.

<sup>b</sup> Transmission line energized.

<sup>c</sup> F = Birds recently killed.

Table 1. Birds found dead under 500 kv transmission line at Orford.



Some bird species that regularly crossed through the line, particularly the long-billed corella *Cacatua tenuirostris* and brown falcon *Falco berigora*, were not found dead.

Some of the smaller species found dead — for example, marsh crake and common starling — were encountered simply by chance, usually when an observer had stopped to record movements of live birds. It was especially difficult to find dead birds during the spring and early summer due to the density and height of the pasture. Some paddocks were not stocked during this period for the purposes of hay production and the pasture height was recorded at up to 0.5 m.

During the winter and early spring when the wetlands were full of water, parts of the transects were submerged and detours had to be made. Skeletal remains of birds were found under the transmission line when the wetlands had dried and access was again possible.

On 11 of 14 times the survey was done, freshly killed birds were found. Avian predators, for example the brown falcon, were recorded on 13 of the survey periods and on four occasions a fox *Vulpes vulpes* or a feral cat *Felis catus* were recorded. Most of the dead birds found had been at least partially eaten. The only exceptions were two straw-necked ibises, one of which was injured when found and later died, a maned duck which was still warm when collected, a spotted crake, a marsh crake and two common starlings.

#### Dead Birds at Darlington

This area was checked on three occasions in June, August, and September 1985. In June 1985 a brolga with a badly dislocated wing and severe bruising was found. The bird died while undergoing veterinary treatment. In addition, six dead black swans and one white-faced heron were collected. In August 1985 four dead straw-necked ibis were collected and in September 1985 two dead black swans.

#### Dead Birds at Hexham (two locations)

In August 1985 six species were found at one location, including nine black swans and one each of the following: brolga, coot, sacred ibis, purple swamphen, and silver gull *Larus novaehollandiae*.

At a second location, twenty species were found over an extended period. Those species not found elsewhere were white-eyed duck *Aythya australis*, grey teal *Anas gibberifrons*, wedge-tailed eagle *Aquila audax*, black shouldered kite *Elanus notatus*, barn owl *Tyto alba*, and grey shrike-thrush, *Colluricincla harmonica*. More than one specimen each of the two ducks were found, and one specimen each of the other species. Of those bird species that were found at other sites as well as at Hexham, the most significant one was an individual Australasian bittern.

#### Dead Birds at Ettrick (two locations)

At one location in June 1986, four black swans and one sacred ibis were collected.

At a second location in October 1986, five black swans, six straw-necked ibis, one sacred ibis, and two Australian shelduck were collected. This count was done at 1500 hours.

The sacred ibis was very fresh and still bleeding. This site is about 350 m north of Ellangowan Swamp, which contains an ibis breeding colony.

## DISCUSSION

The results clearly show that a wide range of species are at risk from collisions with transmission lines, including nocturnal species (owls, bitterns).

The highest numbers of casualties were found during the first two months of the study and could be the result of an accumulation of birds over a period of time prior to the start of the study.

The majority of birds found were physically large species (for example, black swan, ibises, and ducks) which were easy to see and which would be difficult for predators to remove totally from the immediate area. Smaller species are more easily concealed by long pasture and native vegetation. There is therefore a possible bias in our results toward the larger species. Other researchers have also indicated the probability of injured birds (usually larger species) hiding and dead birds (smaller species) being removed from the area by scavengers or predators (McNeil et al. 1985).

In support of this premise, on the second day of the survey in November 1985, a live, injured straw-necked ibis was found in a well-vegetated shallow freshwater marsh located directly under the transmission line. The bird had broken its wing some time previously as the injury had putrefied and become infested with fly larvae. It was not possible to catch the bird at that time, and when we returned two hours later the bird lay dead at the edge of the swamp.

One farmer, who owned property crossed by transmission lines, told us that he made a practice of removing bird carcasses when sheep were lamming in the paddock, in an effort to reduce the presence of foxes among the lambing ewes. The potential for farm dogs to locate and remove carcasses cannot be discounted. Whenever we met farmers during the survey they were accompanied by dogs. The dog of one surveyor (P Du G) participated in the survey on one occasion. It was responsible for the discovery of the blue-billed duck.

Black swans breed opportunistically on wetlands throughout the area. Black swans are a mobile species known often to fly at night (Frith 1977). Being large birds with a body weight in excess of 5 kg and a wingspan up to 2 m, the swans are not able to take rapid evasive action. Brolgas also have a similar lack of maneuverability.

We recorded one pair of swans raising young in a nest directly beneath the transmission line. This particular pair was probably not at risk as the birds would fly well below the transmission line when approaching or leaving the nest site.

The transmission line was also within the area used by feeding flights of sacred and straw-necked ibis. Two breeding colonies of these species occur within 25 km of the study site.

The transmission line towers average approximately 60 m in height. The two lightning conductors or earth wires and the top two sets of main conductors appeared to coincide with the flight altitude favored by many species in their

general movements throughout the area (Figure 4).

Many of the birds probably collided with the transmission line at night or under low light conditions. It is also likely, however, that some collisions occurred during the day particularly among flocking birds and those species that find it difficult to maneuver in strong winds.

When the transmission line became energized, bird collisions continued to occur despite the fact that under damp atmospheric conditions the transmission line emitted an audible crackling noise. Over 20% of bird deaths were recorded on the five occasions that the line was energized.

We are of the opinion that most deaths occur by collision with the earth wires. These are single, small diameter cables and are less visible than the large diameter and grouped main conductors.

#### CONCLUSION

Our results indicate that bird deaths will occur no matter where a transmission line is located. But the potential

exists for higher levels of mortality to occur where the line bisects extensive wetland areas and/or flight paths of birds. The vicinities of breeding colonies of water birds, and breeding and flocking areas of brolgas, appear to be especially sensitive areas.

Ideally, it would be preferable for transmission lines to be placed underground. Where this is not considered practicable (in Australia the cost of such an undertaking is prohibitive), it is suggested that the transmission lines be sited as far away as possible from important wetland areas, particularly those that support breeding colonies and breeding and flocking sites of species at risk from collision.

If this is not practicable, efforts should be made to site the lines parallel to important flight paths. Consideration should also be given to making wires more visible or to increasing the gaps between the lightning conductors and the top set of main conductors.

The preferred option for the proposed 275 kv line from Heywood to South Australia is the southernmost route which avoids the important wetland system to the north.

#### ACKNOWLEDGMENTS

We are grateful to the various landholders for giving us access to their properties for the survey. Wendy O'Flynn provided assistance with the survey. Rory O'Brien of the National Museum of Victoria identified specimens and gave valuable technical advice. Glenda Emmerson and Alison Barker typed the manuscript.

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# COMPENDIUM OF CRANE BEHAVIOR PART 1: INDIVIDUAL (NONSOCIAL) BEHAVIOR

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## ABSTRACT

This paper provides the organizational framework, nomenclature, and abbreviated descriptions for all conspicuous nonsocial behavioral units for all 15 species of cranes. We present eight generalized functional classes of behavior. These classes include about 90 discrete motor patterns that constitute the nonsocial repertoire of all cranes. We present this compendium to facilitate information exchanges among students of crane behavior and to encourage interest in future detailed studies of the descriptive ethology of each species.

## INTRODUCTION

In the field of ethology, there is a fundamental need for standardized terminology in describing animal behavior. Several descriptive terms are often used even for clearly homologous behavioral acts. For example, the action pattern wherein a bird elevates its feathers, then gyrates violently in left-right rotation about the body axis, is termed "Shaking" for ducks (Nice 1962), "Body/Wing-Shaking" for jungle fowl *Gallus gallus* (Kruijt 1964), "Rouse" for the bald eagle *Haliaeetus leucocephalus* (Gerrard et al. 1973), and "Ruffle-shake" for the golden eagle *Aquila chrysaetos* (Ellis 1979). This lack of uniformity in naming even the most basic action patterns is characteristic of the ethological literature today.

While it is inappropriate to impose a rigid system of action pattern titles for all avian species, because different birds do different things, it is important to standardize terminology for homologous action patterns where possible. In this report, we attempt to create a framework of terms, general enough to embrace the variation inherent in a family comprised of 4 genera and 15 species, yet sufficiently precise to allow biologists to identify homologous behavioral acts for any crane species. To do this we identify, describe, classify, name, and report primary context of performance for all known nonsocial behavioral acts for the family Gruidae. Our statements of function and context are not to be considered final or all-inclusive. Indeed, we know that many of the "nonsocial" action patterns presented here appear elsewhere as components of social displays.

Although crane behavior is receiving increased attention worldwide, incomplete ethograms are available for only two species, the red-crowned crane *Grus japonensis* (Masatomi and Kitagawa 1975) and the sandhill crane *Grus canadensis* (Voss 1976; Nesbitt and Archibald 1981; Tacha 1981). Before crane behavior can be adequately evaluated and compared, a standard lexicon including its basic components must be developed.

The behavioral repertoire of even a solitary vertebrate is a complex matrix of intricately interwoven elements. Because an individual animal does not behave in a vacuum, the description of its behavior is further complicated by variability in hormonal states, social situations, and environmental conditions. In order to tease apart, define, and classify each strand of this web, it is necessary to impose a classification scheme that is, to some degree, arbitrary and artificial. Because of the difficulty of this task, this compendium should be viewed as an initial attempt, something to be expanded and modified through time. Also, this paper is not an ethogram, a complete description of the behavioral repertoire of a single species. We present it, however, in the hope that ethograms for all species will develop from this framework.

The units of animal behavior are hereafter called "ethons" (Ellis [1979]; synonymous with Hailman's [1982] "behavioral outputs," Lehner's [1979] "behavioral acts," and Grier's [1984] "acts"). For brevity and clarity, we use the nonspecific term "ethon" (akin to ethology and ethogram) in reference to both active and static behavioral units including all postures, reflexes, sensory acts, action patterns, and even complex social displays. Behavioral se-

quences such as a Foraging bout (composed of the ethons Peck, Probe, Swallow, etc.) are at a higher level of organizational complexity than the ethon and are herein called "activities." A performance bout for an activity consists of a series of performances of one or more ethons.

In naming and classifying ethons and activities, we employed the following conventions. Each was given a brief descriptive title, the first word of which was capitalized. These titles were hyphenated (e.g., Ruffle-shake) if consisting of more than one word, and titles for ethons (but not activities) were in bold face where they first appeared in the classification outline. In choosing ethon and activity titles, we preferentially used the earliest published term, if suitable. Some terms were chosen from the literature on cranes; a few were derived from behavior studies for other bird groups, and others were adapted from the general literature for animal behavior (especially Heymer 1977). Previously published terms were sometimes altered to fit our conventions for verb tense, capitalization, and hyphenation. In generating new terms, we sought brief, unambiguous titles (e.g., homonyms were avoided) that most precisely described the action.

In identifying individual ethons, considerable variability in complexity was allowed. The simplest ethons are reflexes and postures (e.g., Blink and Lie); the most complex are social displays (such as Arching and Warping, described by Masatomi [1983a]). At the other end of the complexity spectrum, some reflexes (e.g., iris dilation) are either so simple or so unlikely to be under voluntary control that we omitted them. It is often possible to detect the use of some sensory abilities (e.g., sight and hearing), hence their inclusion. For others (e.g., taste and smell), detection is difficult, so we omitted them from this paper.

Our division of the behavioral repertoire into social and nonsocial categories, while convenient and realistic for most ethons, is somewhat forced for a few. Surely the exaggerated Preflight-posture conveys a message to flock mates (Tacha 1984) in addition to aligning the bird for takeoff. Even more obvious, the cold weather contraction of the red, featherless cap (Crown-contraction) is included below with other nonsocial thermoregulatory ethons although the expansion of the cap (Crown-expansion), and even the existence of a highly pigmented bare cap, is associated with its role in social display. Finally, from this paper on nonsocial behavior, we exclude all vocalizations (viewing these as primarily social in nature) and all other ethons relating to both inter- and intraspecific social interactions (including parental and filial behavior) except where there is good evidence that these ethons are routinely performed solo.

Before moving into the compendium, a few other conventions must be mentioned. First, the term "adult," as used in the text, refers to fully grown, rather than sexually mature, birds. Second, except where we state that a certain ethon is known to be performed by one or a few species, we either know or believe that the ethon is performed by all species. Upon reading the paper, it will become obvious that, in contrast to social behavior which varies greatly from species to species, the nonsocial repertoire is much alike for all cranes. Finally, the descriptive

ethology of the red-crowned crane by Masatomi and Kitagawa (1975), very important in influencing subsequent behavioral studies, is cited so frequently that we gave it a special abbreviation (MK) in the text that follows. Another paper by Masatomi (1983b) presents much of the behavioral repertoire of several species of cranes. Unfortunately it is available only in Japanese.

This paper is based heavily on our observations of all 15 species of cranes in captivity (ca 270 cranes of 2 species at the Patuxent Wildlife Research Center and ca 110 birds of 15 species at the International Crane Foundation) and, to a lesser extent, 14 species in the wild. Although we believe the behavioral repertoire presented below is nearly complete for the 9 or 10 better-studied species, additional field work with the less-studied species (hooded *Grus monacha*, wattled *Bucconis carunculatus*, demoiselle *Anthropoides virgo*, black crowned *Balearica pavonina* and black-necked cranes *Grus nigricollis*) may result in the identification of a few more ethons.

Undue emphasis on the behavior of captive animals can be a disadvantage. Many ethons disappear, appear out of context, or appear distorted in captivity. Although this report depends heavily on observations of captive cranes, we believe this emphasis has worked to our advantage. For example, we describe 13 ethons for food gathering and food handling whereas previous field studies, hampered by long distance observations and screening vegetation, reported only a few (MK; Voss 1976; Tacha 1987). Similar lack of detail is characteristic of field-based descriptions of Preening and Bathing.

The benefits derived from closeup observation of captive birds are even more evident for social displays. Voss (1977), in a field season working with wild sandhill cranes, observed the Crouch agonistic display only once. By contrast, in a single hour walking through the sandhill crane colonies at the Patuxent Wildlife Research Center, it is possible to elicit Crouch from a score of birds. In the same amount of time, Crouch can be elicited from a half dozen species at the International Crane Foundation. A lifetime of field observations may yield fewer detailed observations of some complex social displays than a single season with our captive flocks. After elaborating on the usefulness of observations on captive birds, we must also state that the value of field studies to validate behavior observed in captivity is self-evident.

## THE BEHAVIORAL REPERTOIRE OF CRANES

- I. **HATCHING:** several motor patterns are likely involved in the Hatching activity. The ethon best studied is the **Surge-pip** (Johnson 1969, Surge-pip), wherein the chick convulsively surges against the shell while the musculus complexus of the dorsal surface of the neck either tilts the head back so the egg tooth pips and then cuts the shell or the musculus complexus holds the head in position so that respiratory and skeletal muscular convulsions break the shell (see Brooks and Garrett 1970; Hartman et al. 1987).

## II. POSTURES

- A. **Lie** (MK, Sit): the posture of an incubating adult with ankles and breast supported on the substrate (see Figure 1). Young birds sometimes Lie prone on one side with legs splayed. Nonincubating, healthy adults seldom Lie, and then, only with legs folded beneath the body.

Figure 1. Lie.



- B. **Sit** (MK, Heel-standing; Voss 1976, Hock posture): like Lie, but the breast is lifted above the substrate and not supporting. The tarsus is roughly parallel to the substrate. The heel, and usually the feet, are supporting (see Figure 2).

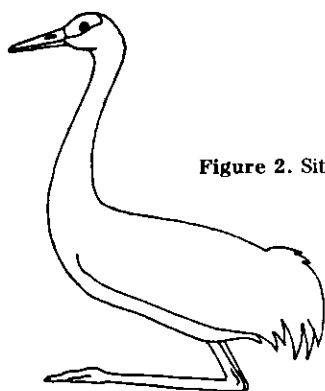


Figure 2. Sit.

- C. **Stand** (MK, Stand or Bipedal Stand): both feet are supporting. African crowned cranes *Balearica* sp. routinely roost in trees (Walkinshaw 1964) and have toes capable of grasping limbs. The other 13 species of cranes typically stand only on the ground; perching in trees, however, has been observed once for a common crane *Grus grus* (Kitagawa and Archibald pers. obs.).
- D. **One-leg-stand** (MK, Unipedal standing): one foot is supporting; the other foot is elevated (or at least nonsupporting) and often tucked out of sight in the feathers of the abdomen and breast. Most commonly seen in cold weather.

## III. SLEEP-RELATED BEHAVIOR

- A. **Head-droop-sleep** (MK, Down-sleeping): one or both eyelids are at least partially closed. Chicks often Sleep with head on substrate. Adults often doze with bill tip drooping downwards, sometimes touching the neck (see Figure 3).

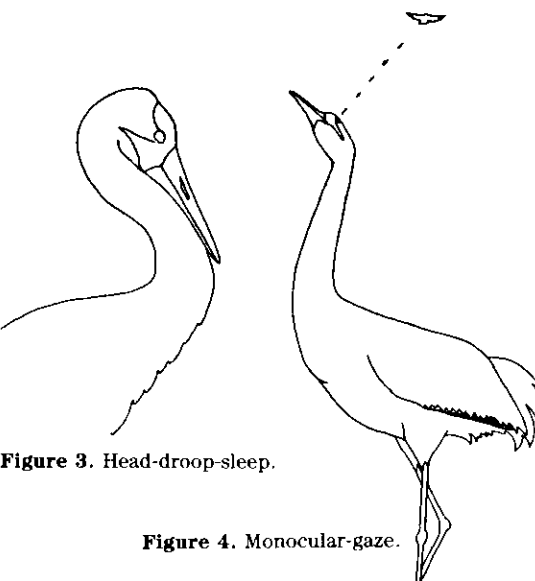


Figure 3. Head-droop-sleep.

- B. **Head-tuck-sleep** (MK, Back-sleeping): Sleeping with the bill resting on or in the feathers of the dorsum.
- C. **Head-tuck-watch** (MK, Sleep-like-resting): like Head-tuck-sleep, but with eyes open.

## IV. SENSORY-RELATED BEHAVIOR: because of the difficulty of relating observable motor responses to sensory abilities for taste, smell, touch, and proprioception, we report none below. While the visual ethons listed below are normally associated with vision in air, underwater gazing has also been observed in the whooping crane *Grus americana*, is very important for the Siberian crane *Grus leucogeranus* which feeds heavily on submerged vegetation (Sauvey 1975), and may be important for several other species. In the Siberian crane, underwater gazing is performed with the nictitating membrane covering the cornea (M. Nagendran, pers. comm.).

- A. **Blink**: the rapid movement of the nictitating membrane as it flashes across the cornea, then quickly refolds along the anterior margin of the eye. Analogous to but not homologous with the mammalian blink wherein the upper and/or lower eyelids quickly close, then reopen. Blink lubricates the cornea and protects it from mechanical injury.
- B. **Monocular-gaze** (MK, Gaze): sideways viewing with one eye dominant as evidenced by a unilateral cocking of the head (see Figure 4). May sometimes be confused with the cocking of the head associated with Listening.

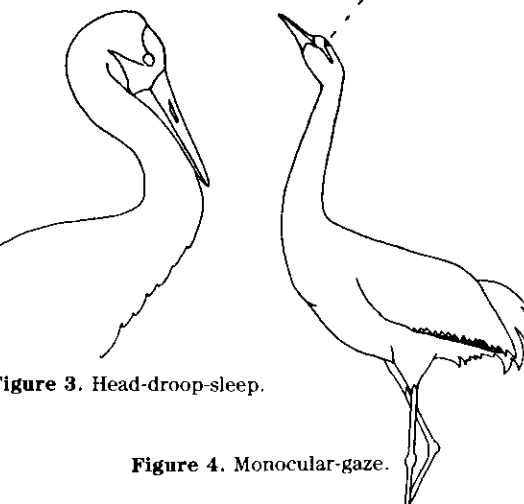


Figure 4. Monocular-gaze.

- C. **Binocular-gaze** (MK, Gaze): forward viewing with both eyes.
- D. **Listen**: other than a lateral cocking of the head (IV B) and obvious responses to sudden sounds, a crane does little to indicate that it is Listening.

## V. MAINTENANCE BEHAVIOR

### A. Care of the Body Surface: this category includes 17 action patterns and 4 activities (i.e., Preening, Oiling, Feather-painting, and Bathing).

1. **Crown-twitch:** a spasmodic front to back jerking of the exposed (naked) crown. Occasionally observed for sandhill, red-crowned, and whooping cranes, but may be present in others. Not yet reported for wattles or other bare areas. Performed in an apparent attempt to dispel insects.
2. **Bill-flick:** a quick left-right jerk of the bill sometimes performed in series or at intervals. Dislodges foreign matter from the bill.
3. **Head-rub** (Kruijt 1964, Head-rub): a slow to rapid rubbing of the inverted head (crown, face, or bill) on the dorsum or wing. Presumably serves to relieve itching, to dislodge debris, and to distribute uropygial oil (V 7).
4. **Fluff** (Voss 1976, Fluff): the elevation (erection) of the feathers of one zone or of the entire body (see also VI A).
5. **Sleek** (Voss 1976, Sleek): the smoothing (depression) of the feathers in one zone or over the entire body (see also VI B).
6. **Preen** (MK, Preen): an activity involving the following four ethons.
  - a. **Dig-in** (Ellis 1979, Dig-in): as the bill is swept in a series of rapid, low-amplitude arcs, the tip of the bill is worked down through the feather layers toward some underlying spot which is then Nibbled.
  - b. **Nibble** (Kruijt 1964, Nibble): rapid, low-amplitude, open-close bill movements while in contact with the plumage or integument.
  - c. **Comb-out** (Kruijt 1964, Comb; Ellis 1979, Comb-out): nibbling a long feather from base to tip while slowly sweeping the bill in an arc.
  - d. **Stroke** (Kruijt 1964, Combing or Stroking; Voss 1976, Back-Slicking): the bill is swept in broad side-to-side arcs, as for Bill-wipe (V A 11) and somewhat like Head-rub, but with the beak either on the feather surface or, very often, not actually contacting the plumage.
7. **Oil** (MK, Oiling): an activity involving Head-rub or Nibble of the uropygial tuft, and Bill-wipe, Preen, Head-rub, and Stroke to apply oil to feathers.
8. **Feather-paint** (Voss 1976, Feather painting): an activity that involves grasping mud or vegetation in the bill (Bite action pattern is used: VIII A 5) and wiping these on the plumage (Stroke V A 6d). Feather-painting is performed frequently by Siberian (Sauey 1985) and sandhill cranes (Drewien 1973), infrequently by common cranes (Libbert 1956)

and hooded cranes, and is unknown for the other species.

9. **Scratch** (MK, Scratch; Heymer 1977, Direct-Scratch): the foot is flicked against the head or upper neck so that the nail or pad of usually the middle toe makes contact with and removes debris from feathers, skin, or bill (see Figure 5).

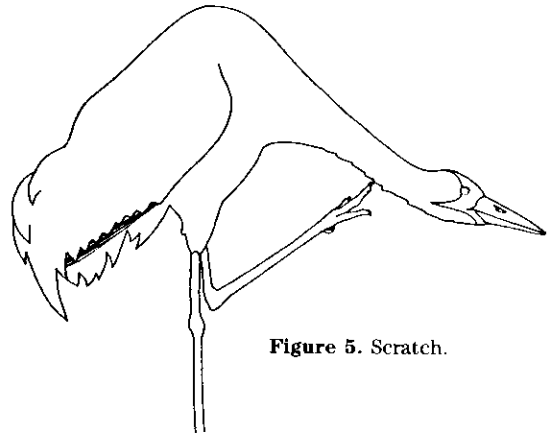


Figure 5. Scratch.

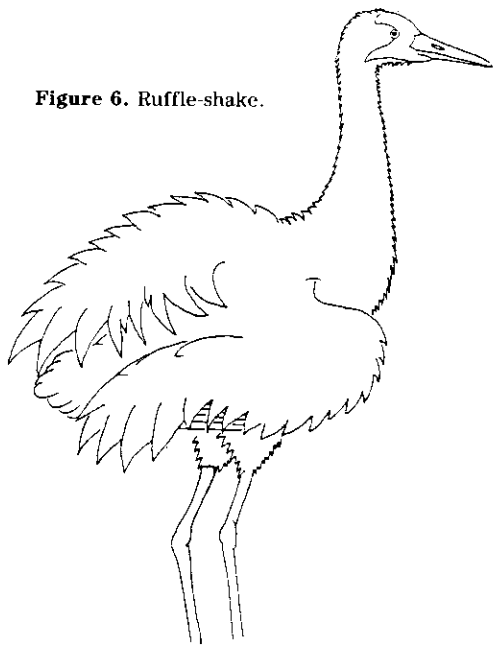
10. **Leg-flick** (MK, Leg-shaking): as the bird One-leg-stands, the tarsus and dorsal surface of the other foot slap one to several times upward and sometimes against the abdomen. The action sometimes dislodges debris (or snow) from the foot and is used to bed the foot in the feathers of the abdomen, especially in cold weather (see also V D 3).
11. **Bill-wipe** (Ellis 1979, Bill-wipe): the bill is cleaned by rubbing against vegetation or substrate.
12. **Bathe** (MK, Bathe): an activity involving the following action patterns and usually performed while Sitting or Standing in water.
  - a. **Bill-slosh:** the side-to-side thrashing of the submerged bill.
  - b. **Head-neck-dip:** the rapid plunging of the head and neck into and out of the water.
  - c. **Wing-thrash:** the plunging of one or both wings into the water and violently thrashing the submerged wing(s).
  - d. **Roll-slosh:** performed by rolling over briefly on the back and thrashing the wings. Seldom observed.
  - e. **Belly-slosh:** the belly is thrust forward and upward rapidly through the water, then less rapidly returned to prethrust position. Performed in one or more brief series.

### B. Comfort Movements: Shaking

1. **Head-shake** (MK, Head-shake and Head-neck-shake): the bill, extended until approximately parallel to the axis of the neck, is gyrated in a brief series of rapid cycles about the axis of the neck. Also appears in close association with 2, 3, and 4 below.

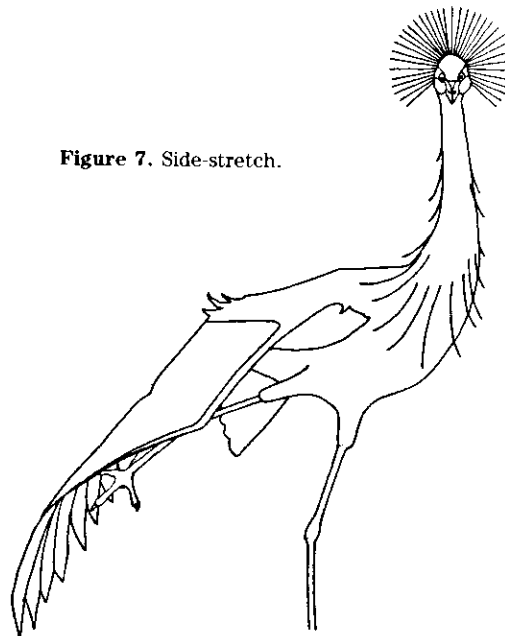
2. **Ruffle-shake** (MK, Body-wing-shake; Voss 1976, Ruffle): a vigorous churning of the body in rapid left-right cycles about the axis of the body (see Figure 6). During a performance, the loosely folded wings flop at the sides and usually the head is lowered. It often follows Fluff and, in captive birds, is frequently seen within a few seconds after a bird is released. This ethon is perhaps merely the full expression of Shiver-shaking and Wing-shaking.

Figure 6. Ruffle-shake.



2. **One-leg-stretch** (MK, Leg-stretch): probably an incomplete (partial) performance of Side-stretch. One leg is extended and stretched down and/or back.
3. **Side-stretch** (MK, Leg-stretch; Voss 1976, Wing-leg-stretch): the extension of the wing and leg of one side and lateral deflection of the tail beneath the extended wing followed by a brief straining interval (see Figure 7). Often performed by chicks while Lying, otherwise performed while One-leg-standing.

Figure 7. Side-stretch.



3. **Shiver-shake**: like Ruffle-shake but the frequency of the cycles is higher and the amplitude of the rotation is decreased.
4. **Wing-shake** (MK, Wing-shake): like Ruffle-shake but performed more slowly and with little body rotation. The folded wings are violently and loosely flopped at the sides but, unlike Ruffle-shake, the wings are shaken simultaneously in symmetry not in left-right rotation.
5. **Tail-shake** (Ellis 1979, Tail-shake): a brief spasmodic rustling of the rectrices caused by the rapid quivering of the pygostyle.
6. **Tail-wag**: a brief side-to-side sweeping of the rectrices. A typical bout consists of several similar left-right cycles performed rapidly but more slowly than for Tail-shake. Much more frequently performed than Tail-shake.

#### C. Comfort Movements: Stretching

1. **Yawn** (MK, Yawn; Voss 1976, Jaw-stretch): the involuntary opening of the mouth, stretching of the mandibles wide apart and straining in the extended position. Often indistinguishable from Gape (VIII C 2).

4. **Two-leg-stretch** (MK, Rump-raising): both legs are simultaneously extended downward (or in Lying chicks, backward), resulting in a lifting of the rump area. Seen mostly in Lying chicks.
5. **Two-wing-spread-stretch** (Voss 1976, Lateral-wing-stretch): both wings are maximally spread to the side and strained briefly.
6. **Bow-stretch** (MK, Wing-raising; Voss 1976, Bow-stretch): the body axis is depressed anteriorly as both folded wings are raised until nearly touching over the back (see Figure 8). The bird briefly strains.

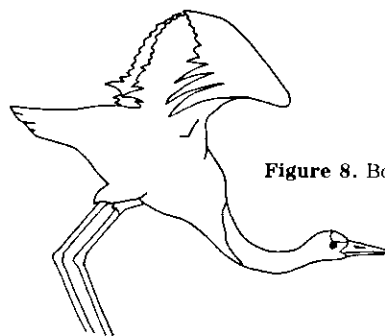


Figure 8. Bow-stretch.

D. Other Comfort Movements

1. **Rise-flap** (MK, Wing-flap): the body axis is raised anteriorly and the crane performs several deep horizontal flaps (see Figure 9).



Figure 9. Rise-flap.

2. **Wing-fold**: the drooping (or extended) wing is quickly lifted to its folded position at body side. Occasionally seen in all individuals, but performed more frequently by fatigued chicks.
3. **Leg-flick**: this action pattern, described in V A 10, appears in three related contexts: as a means of removing snow or debris from the foot, as a precursor to One-leg-stand, and probably also as a comfort movement.

VI. THERMOREGULATORY AND RESPIRATORY: in addition to the ethons described below, this category includes cold weather performances of Leg-flick, One-leg-stand and Leg-tuck Flight (VII C 1).

- A. **Fluff** (Voss 1976, Fluff): birds control the amount of heat loss or gain by adjusting the degree of erection of the contour feathers. Fluff is the elevation of the feathers as when Preening or when cold. See also V A 4.
- B. **Sleek** (Voss 1976, Sleek): compression of the plumage aids in radiative heat loss by decreasing the insulation capacity of the plumage. Performed by moderately overheated cranes. See also V A 5.
- C. **Ruffle**: hyper-elevation of the feathers, performed by an extremely overheated crane and typically accompanied by Panting. Allows for convective heat loss by exposing underlying skin areas.
- D. **Pant** (MK, Pant): rapid breathing with bill at least slightly agape. Allows for evaporative heat loss from the buccal cavity and other moist surfaces of the respiratory system.

- E. **Cough**: a spasmodic exhalation with bill agape resulting in a brief harking or honking sound.
- F. **Sneeze**: like Cough, but bill is closed or nearly so and the resulting sound is quieter. Exhalation is partially nasal.
- G. **Shiver**: a high frequency, low amplitude trembling of the body associated with heat loss and perhaps fear and/or anger.
- H. **Crown-contraction/Crown-expansion** (Voss 1977, Red-crown-expansion): species with featherless areas on the head and neck, expanded for social display, contract these zones in very cold weather presumably to minimize heat loss (see Figures 10, 11). This expansion and contraction is at least partially under voluntary control and is mediated by subcutaneous muscles. For some species, this ethon is more appropriately entitled **Wattle-contraction** or, in general, **Bare-skin-contraction**.

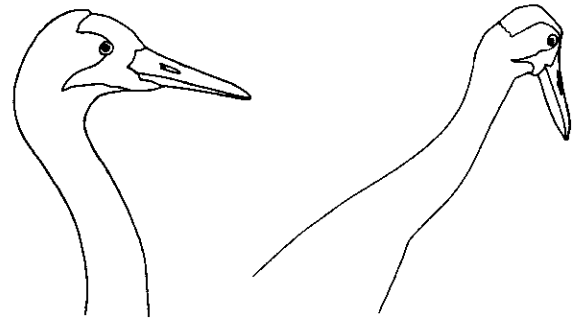


Figure 10. Crown-contraction. Figure 11. Crown-expansion.

- I. **Crest-flare**: some degree of crest or crown flaring is possible in African crowned cranes. Observations of captive birds suggest that the flared crown is sometimes used to shade the drooped head. Further observations are needed to clarify this association.
- J. **Neck-sun** (MK, Neck-sunning): an inactive bird orients its head and/or neck to maximize insolation.
- K. **Wing-spread-droop** (MK, Wing-spread-sunning): like Neck-sun, but performed with neck retracted and one or both wings drooped, often contacting the substrate, especially if the bird is Sitting.
- L. **Wing-spread-hold**: both wings are widely spread and oriented to allow insolation. Particularly common in African crowned cranes (see also VII B 1).
- M. **Urohidrosis**: a form of Defecation (see VIII C 4) wherein the crane ejects excrement onto the scaled portions of its legs. Presumably promotes cooling through evaporation as hypothesized for storks Ciconiidae and New World vultures Cathartidae (Rea 1983). Performed occasionally by red-crowned and whooping cranes and perhaps others.



## VII. LOCOMOTORY

## A. Ambulatory

1. **Waddle**: the bird in Sit posture moves forward or backward by shuffling its tarsi across the substrate. Rarely observed; occasionally seen in chicks or incubating adults.
2. **Walk** (MK, Walking): alternate stepping while in Stand posture. Unlike Running, performed slowly and with at least one foot on the substrate at all times. An exaggerated "high-stepping," performed when traversing unstable ground or while in deep water (Pukinsky and Ilyinski 1977), appears similar to the gait used by sandhill cranes and perhaps other species while approaching the nest.
3. **Run** (MK, Running): like Walking but step length is greater and both feet are sometimes off the substrate. Flapping usually accompanies Running, especially in adults. One form, a rhythmic canter performed with the wings mostly closed, is often seen in large chicks.
4. **Hop**: cranes normally proceed by Walking rather than by Hopping, a form of locomotion common to many small passerines. Occasionally, injured cranes or birds in One-leg-stand in very cold weather will, even in the wild, move short distances by a unipedal skipping action.
5. **Leap**: accompanied by Flapping, cranes often jump vertically when Dancing or fighting, or Leap may be performed solo. Similar to Spring-up (VII B 4) and sometimes signals intention to Fly (Tacha 1984).

## B. Transitional Action Patterns (those following, preceding or signaling intention to Fly): see also Tacha (1984).

1. **Wing-spread-hold**: most often seen for adults in association with the Dance, as a component of Attack, before or after Rise-flap (V D 1), and as a flight intention movement. The wings are spread and held open (see also VI L).
2. **Preflight-posture** (Tacha 1984, Neck-stretch and Neck-stretch-wings-spread): the head is elevated, and the bill is held horizontal or slightly depressed at the tip (see Figure 12). The neck is arched slightly and extended maximally forward. Most often, the wings are held closed or slightly spread. Sometimes they are mostly spread (Tacha 1984). Usually precedes Flight. Two versions are present in the whooping crane: the feathers of the neck base are either Fluffed or Sleeked. The fluffed version likely signals fear or avoidance.

3. **Run-flap** (MK, Dashing and Take-off; Tacha 1984, Neck-stretch-wings-spread-run): Cranes launch by two methods: either they Run while Flapping until they lift off (see Figure 13), or they Spring-up (VII B 4).

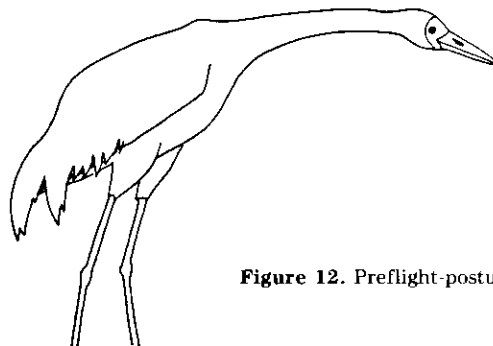


Figure 12. Preflight-posture.

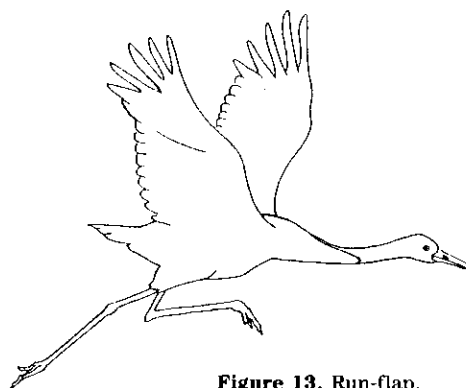


Figure 13. Run-flap.

4. **Spring-up**: launching directly into flight without a preliminary Run-flap performance (see Figure 14). Spring-up is used under extremely alarming conditions, as in response to an attack by a nearby predator.

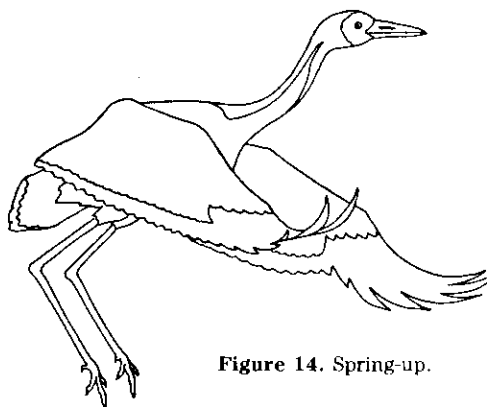


Figure 14. Spring-up.

5. **Alight** (MK, Landing): like the Parachute component of Flight (VII C 3), the legs dangle, the leading edges of the wings are turned upward to affect a stall, and the bird floats downward and forward (see Figure 15).

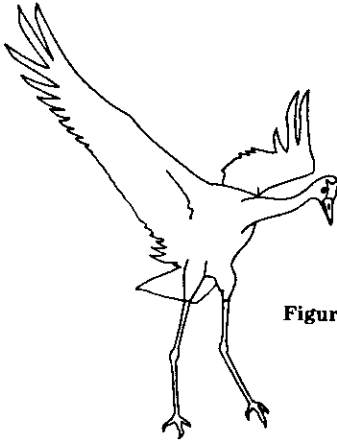


Figure 15. Alight.

C. Flight, an activity consisting of at least the following three ethons.

1. **Flap** (MK, Flap): crane Flight, except during the launch, is facilitated by rather shallow Flaps. In Flapping Flight the legs trail behind, except in extremely cold weather when both legs are sometimes tucked out of sight in the feathers of the breast and abdomen (Walkinshaw 1953; Nesbitt 1978). Leg-tuck Flight has been observed for four species, but is probably present in all fifteen.
2. **Soar and Glide** (MK, Soar and Glide): Gliding and Soaring are perhaps most important on migration when great distances are traversed, but cranes routinely Glide for short distances and brolgas *Grus rubicunda* often Soar at midday, presumably to escape the heat of northern Australia (Archibald and Swengel 1987). While these two action patterns are morphologically much alike or identical, they are functionally somewhat different: Soar is used to rise on an updraft or thermal whereas Gliding is used for straight-line travel. Under the right conditions, most, but perhaps not all, species soar (Johnsgard 1983).
3. **Parachute** (MK, Downward-gliding): grading into Alight (VII B 5), this variation differs from normal Flight in that the legs dangle to some degree and, when fully performed, the wings are rotated downward posteriorly to promote stalling, and the neck is partially retracted (see Figure 16).

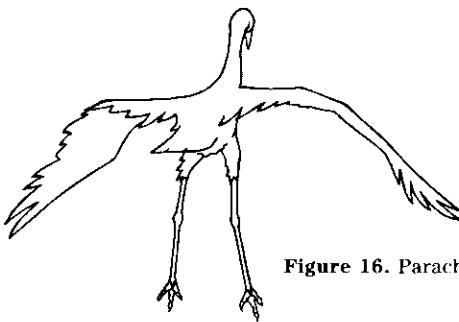


Figure 16. Parachute.

D. **Swim** (MK, Swimming): consists of floating and leg paddling, and is most often performed by chicks, although adults are fully capable of Swimming.

VIII. INGESTION, EGESTION, AND EXCRETION (food-related activities and action patterns): Tacha (1987) divided ingestion-related activities into three classes: Gleaning, Probing, and Drinking. Most of the food-related action patterns listed below have not been described previously in the literature on crane behavior. Scratching of the substrate, although reported for the sandhill crane (Guthery 1972 in Voss 1976), is believed to be unimportant or absent.

A. Foraging: an activity class that includes the food-gathering and food-handling action patterns listed below and other activities such as Walking in search of food and Binocular-gazing.

1. **Stab**: a high-amplitude, forceful bill thrust directed toward a large food item or other object. The motor pattern is probably equivalent to Probing the substrate. A variation of Stab is performed by black-necked and Siberian cranes foraging for submerged animals in turbid water. They repeatedly plunge the head and bill into the water and contact prey somewhat by chance.
2. **Probe** (Tacha 1987, Probe): like Stab, hut the blow is directed at the substrate.
3. **Peck**: a low-amplitude and low-energy bill thrust often terminated by the grasping of an object.
4. **Nibble**: as for the Nibble component of Preen (V A 6 b), the bill performs rapid, low-amplitude, open-close movements while in contact with an object.
5. **Bite**: grading into Nibble, but with greater amplitude of head movement and intensity of grasping. In addition, the grasping action is usually performed only once for Bite rather than in rapid series as for Nibble. Some head twisting may accompany the Bite.
6. **Tug**: bite accompanied by a neck retraction (pulling) motion.
7. **Thrash**: an object is grasped firmly in the bill (Bite), then shaken violently with rapid side-to-side and, to a lesser degree, long-axis rotational movements. Cranes often Thrash larger food items in water, but sometimes do so on dry ground.
8. **Bash**: a firmly grasped (Bitten) object is slapped (usually repeatedly) against the ground or a solid object.
9. **Bill-flick**: as illustrated by Tacha (1987), cranes flick soil and other debris out of a shallow pit excavated by their Probing activities. During the Bill-flick, the head is rotated quickly about the axis of the neck so that the bill tip is swept to one side in a

shallow arc, then quickly returned to its vertical orientation.

10. **Bill-side-push**: when Foraging, vegetation and soil are moved from the target area not only by the Bill-flick, but also by a forceful lateral push by the bill against the vegetation or the wall of the excavated pit.
  11. **Bill-push-open**: the third action pattern serving to expose the probe site. The mandibles are forcefully pushed open while the bill is deep in the feeding pit.
  12. **Bill-wipe**: treated also under Care of the Body Surface (V A 11). While foraging, cranes wipe debris from the bill by rubbing on vegetation or substrate. Sometimes observed in close association with foraging bouts.
  13. **Stomp**: crowned cranes flush insects by slapping a foot against the ground or vegetation (Pomeroy 1980).
- B. Swallowing: whether eating or Drinking, all variations of the Swallowing action patterns, described below, include in-out tongue movements and up-down throat movements.
1. **Nibble-swallow**: with the bill pointing downward (usually), a small food item (or some other object) is moved toward the pharynx by Nibbling movements (VIII A 4).
  2. **Toss-swallow** (MK, Eat): larger food items are moved into the pharynx by a jabbing movement of the head coordinated with grasping and releasing movements of the bill resulting in the object moving approximately 2 cm up the bill with each toss cycle. In the wild, Toss-swallow is routinely used to move solid objects, but captive whooping cranes sometimes drink from a watering cup by tossing water.

3. **Drink or Scoop-swallow** (MK, Drink): cranes typically Drink by scooping water into the bill, then lifting the head and opening and closing the bill in rapid cycles.
4. **Neck-pump**: objects not moving easily in the upper esophagus are forced up or down by a pumping or craning of the neck accompanied by Swallowing movements.

#### C. Egestion and Excretion

1. **Bill-shake**: the bill, while held approximately perpendicular to the axis of the neck, is swept in a series of rapid, high-amplitude, left-right arcs. Expels objects and fluids from the pharynx, nares, and bill. Often performed with bill open and often accompanied by Coughing and Sneezing (VI E, F).
2. **Gape**: voluntary opening of the mouth to the full extent. Empirically, much like Yawn (V C 1) but without the straining component common to stretching ethons. Serves to move objects in the pharyngeal region.
3. **Vomit**: fluids and solid objects are expelled from the bill in part by Gaping, Bill-shaking and Neck-pumping motions. Also important, however, are the not readily visible contractions of the upper digestive tract and the abdominal muscles forcing food (and other material) up the esophagus. Vomit, a reflex probably only partially under voluntary control, is somewhat different from Regurgitate, a type of parental feeding behavior common in many bird taxa but not cranes.
4. **Defecate**: feces are expelled vertically downward in a fluid jet, sometimes following a slight squatting motion (posterior movement of the body and/or elevation of the rump). See also Urohidrosis (VI M).

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## SAMPLING METHODS FOR AERIAL CENSUSES OF NESTING FLORIDA SANDHILL CRANES IN CENTRAL FLORIDA

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### ABSTRACT

Florida sandhill crane *Grus canadensis pratensis* nests on the Webb Wildlife Management Area in central Florida were aerially surveyed from mid-January through mid-May during 1986, as part of an evaluation of potential release sites for a third flock of whooping cranes *G. americana*. A systematic (versus random) aerial sampling design was developed that used fixed-strip transects. A Loran C (Long Range Navigation) receiver enabled us to repeat transects between flights. By combining the data from unique nest sightings over the 10 nest surveys, the 1986 breeding population was estimated at  $211 \pm 62$  breeding pairs for the 405 km<sup>2</sup> study area. The advantages of systematic transects are discussed in relation to the problems involved in aerial censuses.

### INTRODUCTION

Aerial surveys using either photography or trained observers can be an effective method of censusing crane populations. When a species or its nest is large or conspicuous, and the census area is large and not readily accessible by ground, aerial surveys may be the only practical means to obtain the necessary data. While a total count of a crane population using aerial techniques may be a desired objective, it can be difficult and expensive to achieve because total counts require good maps, complete coverage of the census area, and an assurance that all animals are counted (Norton-Griffiths 1975).

A preferred and less expensive alternative to a total population count is aerial sampling. There are three basic aerial sampling methods: transect, quadrat, and block. Transect sampling, counting animals while flying in a straight line from one side of the sampling unit to the other, is the most popular method and offers several advantages. It is cost effective, physically comfortable for the observer, and easy to navigate and orient. With respect to statistical analyses, transects produce a lower variance and sampling error than blocks or quadrats. This is because transects tend to reduce the effect of animals clumping together (Norton-Griffiths 1975).

From 1984-1986 the University of Florida Department of Wildlife and Range Sciences conducted aerial transect surveys for nesting Florida sandhill cranes in central Florida. The Florida sandhill crane is a nonmigratory subspecies that occurs from Okefenokee Swamp in

southeast Georgia south to the Florida Everglades in southeastern U.S.A. In central Florida, this subspecies has a long nesting season, extending from January through the end of May.

The nest surveys were part of a larger study designed to evaluate three Florida sites proposed for whooping crane reintroduction (see Bishop and Collopy 1987). The objectives of the nest surveys were to: (1) map the seasonal distribution of nesting pairs and (2) estimate the density of the Florida sandhill crane breeding population on the three sites and their surrounding areas. This paper reviews the aerial methodology and data analyses used for nesting surveys during 1985 and 1986. Results for the 1986 breeding season on one of the proposed sites, the Webb Wildlife Management Area, are presented.

### STUDY AREA

The Webb Wildlife Management Area (WMA) consists of 26,454 ha in Charlotte County, Florida. The study area included not only the potential whooping crane release site, but also surrounding private lands, primarily along the southern and eastern borders. For 1986, the study area comprised 405 km<sup>2</sup>.

The Webb WMA has flat topography and is characterized by poorly drained, sandy soils with an underlying clay hardpan. Dominant vegetation cover consists of two similar types: broad saw palmetto *Serenoa repens* prairies (44%) and pine flatwoods (28%), characterized by South Florida

slash pine *Pinus elliottii* and an understory of saw palmetto and wiregrass *Aristida* spp.. Freshwater marshes, wet prairies, and intermittent ponds comprise 21% of the land area and are scattered throughout the management area (Florida Department of Transportation 1978). Cattle grazing is permitted on all but 3,100 ha of the Webb WMA. Cattle ranching and timber are the major land uses on large private tracts that adjoin the Webb WMA to the east. Portions of the north, south, and west sides of the Webb are settled with housing developments.

Annual rainfall on the Webb WMA averages approximately 126 cm, and is unevenly distributed through the year. Over 70% of the rainfall occurs during the wet season from May to October.

#### DATA COLLECTION

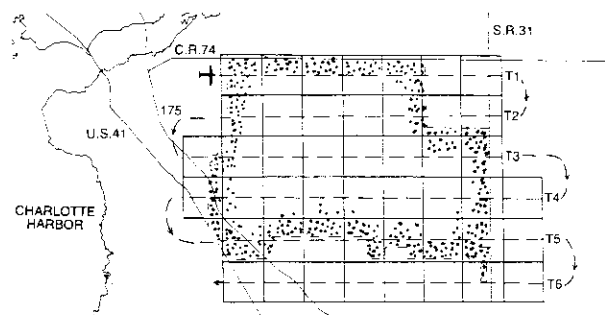
Aerial sampling for Florida sandhill crane nests was considered the most accurate and efficient means of estimating the size of the local breeding population due to the large size of the study area, the heterogeneous terrain, and the long breeding season. For 1986, bi-weekly aerial surveys began 15 January and ended on 8 May.

We used systematic aerial fixed-strip transects during our aerial surveys. Compared to random sampling, systematic sampling is the most efficient means of mapping the distribution of animals, and for comparisons over time of numbers observed on a specific site. Systematic sampling also avoids the navigational problems associated with random transect sampling (Caughley 1977). When our study began, systematic aerial fixed-strip transect sampling was already being used successfully in the Florida Everglades National Park (South Florida Research Center 1985) to estimate wading bird populations and their spatial distributions.

With systematic aerial transect sampling, predetermined and consistently-spaced parallel transects are flown across the study area. Initially, a grid system is established, then flight lines are spaced to bisect each row of grid squares (Figure 1). For our study, a 3 km × 3 km grid system was drawn on the study map. Six east-west flight lines were determined for a total of 135 km. Transect lengths ranged from 20.1-25.4 km. Our transect boundaries usually were landmarks such as powerlines, roads, or lakes.

The survey plane was a four-seat, high-winged, single-engine Cessna 172 Skyhawk. A high-wing aircraft was required to assure an unobstructed downward view and to define our transect strip. Our plane was equipped with an Apollo I Loran C receiver manufactured by II Morrow, Inc., Salem, Oregon. The Loran C is a radio navigation system consisting of a chain of 3 - 5 fixed land-based stations transmitting in the low frequency band of 100 KHz. Each station transmits synchronized pulses at precise time intervals. The Loran C receiver tracks the transmitting stations and converts their signals to the user's actual geographic position (II Morrow Inc. 1983).

In addition to providing present position coordinates, the Loran C receiver can be programmed with starting



**Figure 1.** Layout of a systematic aerial fixed-strip transect survey using 3 km × 3 km grid mapping on the Webb Wildlife Management Area, Florida. Boundaries of Management Area are shaded.

and ending latitude and longitude points for each transect. The transect can be repeated accurately by means of the Loran C receiver's panel-mounted course deviation indicator. Depending on the model, however, the Loran C receiver may need to be calibrated at a known point before beginning each survey to assure accurate repetition of transects.

The Loran C receiver continuously displays the plane's current position either as latitude and longitude coordinates, or as the nautical distance to the desired destination. We recorded the Loran C location of each nest along with a quick hand-drawn picture of the wetland's shape. For our study, we found that nautical distance was faster and less confusing to read and record than the current longitude. After each flight we were able to pinpoint the nest using a combination of 1:24,000 Mark Hurd aerial photograph maps and United States Geological Survey topographic maps.

For each survey, our starting point was chosen randomly from one of the four study area corners. We selected 91 m and 145 km/hr as the optimum plane height and speed for spotting nests and for aircraft safety. Each of two observers, one in the front with the pilot and the other in the back seat directly behind the pilot, recorded all active nests detected within a 200 m interval. Thus, 13% of the total study area was sampled during each survey. The 200 m fixed-strip width for each observer was established by maintaining a constant plane height and defining each observer's visual boundaries. Each observer's strip width was defined by that area viewed between two streamers attached to the wing struts and marks on the windows. The exact position of the streamers and window marks were calculated using a method outlined by Pennycuik and Western (1972).

Florida sandhill cranes in central Florida generally build their nests with emergent vegetation in relatively small, shallow wetlands less than 1 m deep (Walkinshaw 1981; this study). Nests on dry land are rare and have been reported on only a few occasions during this century. Although sandhill cranes are difficult to observe from fixed-wing aircraft because of their cryptic coloration, their nests usually are large and conspicuous. Because the cranes often build more than one nest initially, we counted a nest only if: (1) a crane was on it, (2) an egg was visible, but

there was no crane present, or (3) adult cranes and chicks were on the nest.

## DATA ANALYSIS

In order to estimate the breeding population we used a ratio-estimation method for unequal length transects. This method was popularized by Jolly (1969) and is referred to as the Jolly II method.

The density of breeding pairs/km<sup>2</sup>, for each survey was estimated using the following formula:

$$\hat{R} = \frac{\sum y}{\sum z}$$

where  $y$  is the number of nests counted in the transect, and  $z$  is the area (transect length multiplied by total strip width) of a sample transect.

The estimated population size for each survey is:

$$\hat{Y} = \hat{R} \times Z$$

where  $Y$  is the estimated breeding population.  $Z$  is the total area of the census zone, and  $R$  is the estimated density.

The sample error of  $Y$ ,  $SE(Y)$ , is estimated as  $\sqrt{\text{var}(\hat{Y})}$  where

$$\text{var}(\hat{Y}) = (N(N-n)/n)(S_y^2 - (2 \times \hat{R} \times S_{zy}) + (\hat{R}^2 \times S_z^2))$$

In this formula,  $N$  is the number of potential transects (the number of transects flown divided by the proportion of the area covered, 0.133 for our surveys),  $n$  is the number of transects in the sample,  $S_y^2$  is the variance in number of nests counted in the transects,  $S_{zy}$  is the covariance between the nests counted and the area per transect, and  $S_z^2$  is the variance between the areas of all the sample transects.

The 95% confidence interval (C.I.) of  $\hat{Y}$  is:

$$\text{C.I.} = \pm t \times SE(\hat{Y})$$

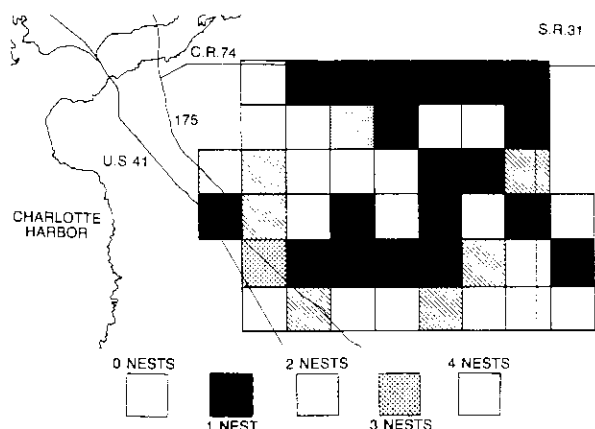
where  $t$  is for  $n-1$  degrees of freedom, and  $SE(\hat{Y}) = \sqrt{\text{Var}(\hat{Y})}$ .

In order to estimate the breeding population for the entire season, only unique nests (no repeat sightings) were totaled for each transect for all flights combined. Density, total breeding pairs, and sample error were calculated using the above formulas. Final estimations were then adjusted downward to account for renesting. We used a 35% adjustment figure based on a recent study of incidence of renesting in Florida sandhill cranes (Nesbitt, pers. comm.).

All our analyses were calculated quickly and efficiently on a microcomputer using a LOTUS® 1-2-3 spreadsheet program. The formulas used can be obtained by writing the senior author c/o the International Crane Foundation.

## RESULTS and DISCUSSION

In 1986, 38 unique nests were observed on transects during 10 aerial surveys conducted between January and May. The distribution of the nests indicated a very low use of areas along the south and southeast portions of the study area (Figure 2). Our southernmost transect was on private



**Figure 2.** Spatial distribution of Florida sandhill crane nests by 3 km × 3 km grid cells observed during 10 systematic aerial transect surveys on the Webb Wildlife Management Area, Florida, January-May, 1986. No repeat sightings were included.

lands which included few large, undeveloped parcels with suitable nesting habitat.

For the 1986 breeding season, the adjusted density and total population estimates for the season are 0.52 breeding pairs/km<sup>2</sup> and 211 ± 62 breeding pairs, respectively, for the 405 km<sup>2</sup> study area. We are confident that this is a reasonable estimate of the breeding population for this area given the water conditions in 1986.

When a 1986 breeding population estimate is calculated for each observer, the front seat observer's estimate was 222 ± 54, and the back seat observer's 200 ± 119. While the estimated means are not far apart, the back seat observer's variance is over four times that of the front seat observer's. This larger variance may indicate a back seat disadvantage both for viewing and for passenger comfort.

Estimated densities ranged from 0.04-0.20 breeding pairs/km<sup>2</sup> per flight. The corresponding estimated total breeding population ranged from 15 ± 24 to 83 ± 71 per flight (Figure 3). Peak nesting occurred on 12 March, approximately the same time (9 March) as during the 1984 nesting season (Bishop and Collopy 1987). The low numbers of nests counted in transects, and the high variability between transects for each survey and over the whole season may make the assumption of normality inappropriate. For 8 of the 10 flights, the 98% confidence intervals for our population estimate contained negative numbers, when in reality the lowest possible value can only be zero. A statistical theory correction could be made by increasing the number of transects or increasing the number of nests sighted.

Transect repeatability, as measured by nest resightings, was 29% ( $n=11$ ) for the season. Of the 11 nests resighted 6 were resighted the following survey (11-14 days later), 3 were resighted 2 surveys (27-28 days) later, 1 nest was resighted 3 surveys (42 days) later and another resighted 4 surveys (59 days) later. We believe that transect repeatability could have been improved significantly if: (1)

there had been a navigator to keep the pilot on course and to monitor plane height, (2) we had not had to use multiple pilots (4 pilots during 10 flights), and (3) the Loran C receiver had been the same model throughout all surveys.

On 30 January, a four-seat Jet Ranger 206-BIII helicopter was used to test how flight speed effects nest detectability. Transects flown the previous day in a fixed-wing aircraft were repeated by helicopter using the same methods described above, except that the speed was maintained at approximately 120 km/hr. The estimated total number of breeding pairs and the confidence intervals were calculated using the same analyses as for the fixed-wing aircraft surveys.

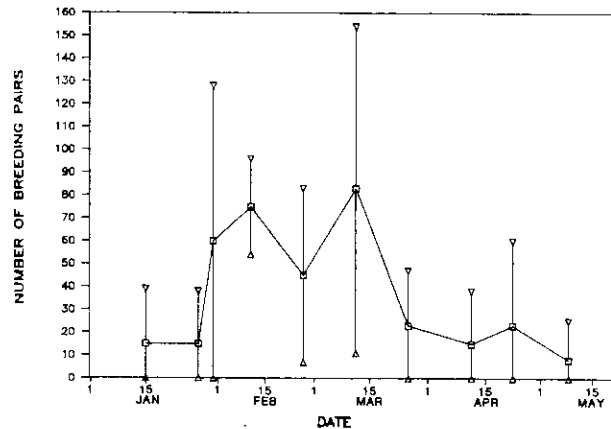
Eight nests were seen from the helicopter, as compared with two nests seen from the fixed-wing aircraft the previous day. Only one of the two nests from the previous day was relocated, and it was empty. The large difference between the two surveys can in part be explained by problems with transect repeatability. The aircraft were equipped with different models of Loran C receivers. The Apollo I Loran C receiver, used in our fixed-wing aircraft, calculates latitude to 0.01 minutes (20 m). The helicopter we used contained a Arnav R-20 Loran C receiver (manufactured by Arnav Systems, Portland, Oregon) that calculates latitudes within 0.10 minutes (200 m) and could not be recalibrated for our known fixed spot, forcing us to readjust all of our flight line latitudes. In addition, the 200 m strip width seen from the helicopter was not at the same angle as that set for the observers in the fixed-wing aircraft.

Two transects flown during the helicopter survey had been purposely altered from the previous day: flight latitude over one transect was changed due to logistical problems with television towers, and the other transect had been extended. Five of the eight nests observed from the helicopter were on these two transects.

The results of our helicopter survey on the Webb WMA suggest an advantage in nest detectability using helicopters. In this instance, there was a large difference in population estimates between the fixed-wing and helicopter survey (Figure 3). Three similar helicopter surveys on our other two study areas, however, did not yield results that were consistent with those obtained on the Webb WMA. On one study area no nests were observed from the helicopter whereas the previous day two nests had been observed with the fixed-wing aircraft (unpublished data, this study). While helicopter surveys may increase the numbers of nests observed, the higher costs associated with helicopter surveys, as much as 2.5-4x the cost of a fixed-wing survey, may be prohibitive.

## CONCLUSIONS

Systematic aerial transect sampling is an excellent sampling method to use when cranes or their nests are easily detected, habitat is relatively flat and heterogeneous, and a precise population count is not essential. When compared with other methods to estimate populations, systematic



**Figure 3.** Estimated population of breeding pairs  $\pm$  95% confidence intervals, by flight for Webb Wildlife Management Area, Florida, January-May, 1986.

aerial transect sampling methodology has several advantages:

1. A large area can be covered quickly and efficiently. It can be an excellent method for a large-scale, ecosystem study.
2. The method gives a good indication of nesting over time; it reveals both the distribution and the spatial patterns of nests.
3. It requires minimum manpower; observers and pilots, however, should be well trained.
4. With proper control over the variables such as plane height, flight line, and Loran C receiver calibration, transects can be repeated accurately.
5. Loran C receivers are relatively inexpensive (US \$750-\$8,000).
  - a. The system is available worldwide including the United States, parts of Japan, the Mediterranean, North Sea regions, the Arabian Peninsula, U.S.S.R. and, more recently, parts of the People's Republic of China.
  - b. The Loran C receiver allows you to pinpoint a nest and later visit the nest on the ground.

Disadvantages of systematic aerial transect sampling include:

1. Population estimates may be accurate but not precise.



2. It is difficult to control the transect repeatability. Ideally, there should be a navigator, a skilled pilot, and several trained observers that can work well as a team.
3. There is a potential for a counting bias due to detectability problems. This bias can be difficult to measure.
4. Pilot error such as banking or flying at incorrect heights will effect the strip width.
5. The conductivity of the Loran C signals, and the accuracy of the Loran C receiver can be affected by certain terrains, adverse weather conditions, time of day, and proximity to Loran C transmitting towers.

#### ACKNOWLEDGMENTS

We especially thank the principal pilot, Paul Eddy, and our second observer, Mark Franklin, for flying the nest surveys. Personnel at the Webb Wildlife Management Area have been helpful throughout the project. This study was supported by the University of Florida's School of Forest Resources and Conservation, the Florida Game and Fresh Water Fish Commission, National Audubon Society, U.S. Fish and Wildlife Service, Cooperative Fish and Wildlife Research Unit, the Henry and Kathryn Mills Charity Foundation, and the Florida Chapter of the Sierra Club. The senior author thanks the International Crane Foundation, the International Programs in the Institute for Food and Agricultural Science and the Graduate School, University of Florida for travel grants to attend this conference.

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## ROCKET-NETTING GREATER SANDHILL CRANES ON THEIR BREEDING GROUNDS AT SENEY NATIONAL WILDLIFE REFUGE

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### ABSTRACT

During April and August-October, 1984-86, 175 greater sandhill cranes *Grus canadensis tabida* were captured by rocket-netting on their breeding grounds at Seney National Wildlife Refuge, Michigan. Most capture attempts were made on drawn down pools or in upland fields. Bait was ear corn or shelled corn placed 3.5 m in front of each folded 15-17 x 10-12-m net. An upward rocket angle of 27° safely minimized escape. Most netting sites were selected so that they could be checked from a vehicle 200-900 m away. Rockets were detonated from blinds constructed of conifer branches and live trees positioned on island or upland ridges 50-175 m from each net. Most efficient use of time and manpower was achieved by entering the blind from the back side of the ridge, out of view of birds on the netting site, after cranes were seen near the bait pile. With few exceptions, rockets were detonated only when all birds had heads down and were standing no closer than 2.5 m in front of the net. Normally each net firing was directed at a small number of birds (two to five). Mean capture rate was 2.9 cranes per shot ( $N = 65$  shots). These procedures resulted in a low casualty rate; observed condition of birds at release and subsequent resightings revealed that one bird died and another sustained a serious wing injury. Both casualties could have been avoided with technique or equipment modifications. Bait piles were frequently revisited by previously captured birds. Limited spring netting suggested no adverse effects on nesting behavior. The major problem associated with the technique was consumption of bait by Canada geese *Branta canadensis*.

### INTRODUCTION

Previous efforts to capture migratory sandhill cranes have been made primarily on migration stopover or wintering areas and usually were directed at large numbers of birds (Wheeler and Lewis 1972, Ramakka 1979, Tacha et al. 1981, Williams 1981). We have concentrated on capturing individual adult pairs, especially those with fledged young, on their breeding grounds at Seney National Wildlife Refuge (hereafter called Seney) in the Upper Peninsula of Michigan. We have determined nest locations, movements, territory size, and breeding success of individual pairs, and have charted the migration route, including stops and wintering areas. Individual color-marking and radio-tagging of the cranes on Seney have been essential to satisfying these objectives, and rocket-netting has been the only effective technique for capturing these adults and fledged young.

### STUDY AREA

All capture attempts were made on Seney (38,630 ha), which consists of about 65% wetlands, mainly sedge *Carex* spp. and cattail *Typha latifolia* marshes and sphagnum *Sphagnum* spp. bogs, and 35% uplands dominated by red pines *Pinus resinosa*, jack pine *P. banksiana*, aspen *Populus tremuloides*, and northern hardwoods. More than

2,800 ha of open water are contained in 26 major pools, 21 of which have water control structures. Several pools were normally drawn down during summer and provided the primary rocket-net sites. The refuge also contains several isolated upland meadows that were good capture sites. During August 1984 to October 1986, rocket-netting was attempted on 33 different sites in 24 general areas (Figure 1).

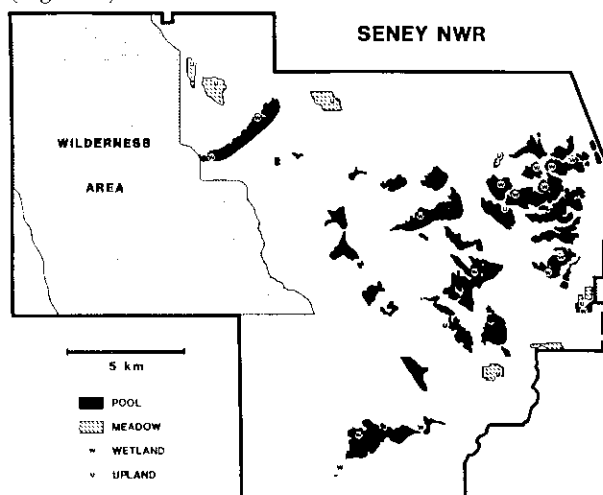


Figure 1. General areas of Seney NWR where sandhill cranes were rocket-netted, 1984-86.

## METHODS AND MATERIALS

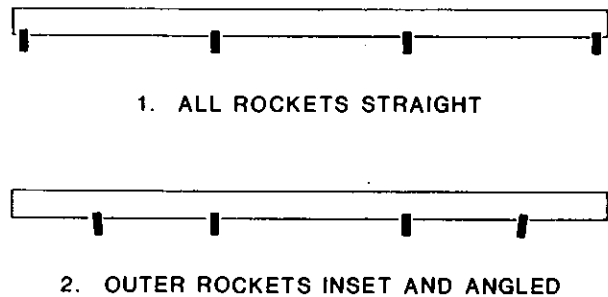
One to seven rocket nets were operated concurrently during 24 August to 30 September 1984, 16 April to 10 May 1985, 1 August to 11 October 1985, 14 to 28 April 1986, and 1 August to 8 October 1986. During 1984 we caught cranes opportunistically, but during 1985-86 our priorities, in order of importance, were to capture and color-mark (1) successful parents (i.e., adult pairs with fledged chicks), (2) adult pairs without chicks, and (3) subadults. Normally a transmitter was placed on one adult, usually the male, of each pair, and all birds captured were uniquely marked with vinyl leg bands. Because successful parents could potentially be used in future attempts to cross-foster endangered whooping cranes *Grus americana*, any capture-related mortality of successful parents was considered unacceptable; net setup and operation were therefore designed to minimize risk.

Each net setup consisted of a net, three to four rockets, anchor stakes, and a two-conductor wire connecting the charges in the rockets to a detonator in a blind. Nets were 15.0 to 17.2 m in length, 10.3 to 12.0 m in width (the dimension projected forward during a shot), 0 to 0.5 m in skirt width, 25 to 40 mm mesh, and 11 to 32 kg in weight. We preferred to fold nets fanwise in 0.5-m-wide folds on a clean, flat surface and carry the nets rolled to each site. This procedure made nets easier to fold, eliminated foreign matter in the nets, facilitated transfer of nets to sites, and resulted in low profile of the net on the ground. If a site proved unproductive, the folded net could be easily rerolled and transferred to another site.

We used three types of rockets, 3.4 - 3.7 kg in weight, having shaft lengths of 235 - 550 mm. Rockets were shot out of the ground, so the longer shafts made aiming and stabilizing rockets easier. Launching stakes were not used. Rockets were aimed upward at an angle of 25° - 34°. In 1986, angles of 24 set rockets were determined by sliding a tight-fitting mailing tube, about 1 m long, over the nose of the rocket and measuring the critical distance from the base of the rocket to the feet of an observer standing directly in front of the rocket and sighting into the mailing tube. The angle was then calculated as the arctan (1.61 m/critical distance). The numerator (1.61 m) was the distance of the observer's eye above the ground.

During 1986 we examined the effects of altering the horizontal angle of the rocket (as measured from the back edge of the net) on net deployment. We measured rocket-landing points of five shots made with all rockets pointed straight and five shots with the outer rockets inset about 2 m from the ends of the folded net and angled outward (about 7°) to shoot the corners - i.e., aimed to the points at which the end rockets should land if the net landed fully spread (Figure 2).

Most sites were prebaited for several days before the net was set. Bait consisted of ear corn or a mixture of ear and shelled corn. Bait sites were established in areas where cranes had been seen consistently. About 25 kg of bait were arranged in a discrete pile about 0.4 m wide and 2.2 to 4.0 or 5.0 m long. A short pile was used when the set was made



**Figure 2.** Two methods of positioning rockets used in tests of net development (not to scale).

to catch a pair or a pair with a chick. Longer piles were used when larger groups were expected to use the site. Husks were removed from ear corn; otherwise cranes pulled ears off the pile and fed on them elsewhere. The distance from the center of the pile to the front of the net, 3.5 m, was critical because shots were made only when birds were at the pile and had heads down. Birds in this position had low probability of either escape or injury. With few exceptions, no shots were made unless all birds were at least 2.5 m in front of the folded net, which was camouflaged with hay or natural vegetation. Rocket charges were detonated with generator-powered blasting machines, 10 or 50 blasting cap capacity.

All detonations were made from blinds constructed of cut conifer branches woven into existing vegetation or into cut trees placed in post holes. Cranes showed no aversion to these natural-appearing blinds. Each blind was located on an elevated site 50 - 175 m from the net ( $\bar{x}$  = 85 m,  $n$  = 4). Good visibility of the net site was crucial: the bait pile, camouflaged net, and birds' position relative to these reference points must be obvious. Sighting through binoculars was necessary at most sites; normally, it was desirable to see a bird's feet to verify its exact position. The best angle of sight from blind to net, relative to the net, was 45°. This angle gave good perspective to determine both that the birds were the correct distance from the net and that they were not too far from either end of the bait pile. All blinds were located so that they could be entered without the netter being seen by birds at the net site.

Two methods were used to operate the nets. The first method was of limited value and involved waiting in the blind for birds to arrive in early morning. This method was feasible only when birds consistently fed at the same site each day, as in certain upland fields during August and early September.

The more versatile and efficient method of operating the nets involved checking several net sites from a vehicle stopping at vantage points along a driven route. These vantage points were 200 - 900 m from the net sites. Most sites had check points at least 400 m away because at less than this distance the vehicle often caused the cranes to stop feeding or to flush from the site. This method worked especially well on drawn down pools. A series of net sites was checked until one containing cranes was found; we then moved the

vehicle out of view and proceeded on foot or by canoe to the blind along a trail blocked from the net site by islands or elevated land. This procedure allowed birds to be captured at any time of day, and personnel time was expended only at productive capture sites.

A crew of one to five people processed captured birds. The tarsi of each captured bird were first taped together. Cranes were then removed from the net and placed in burlap bags for processing.

## RESULTS AND DISCUSSION

During 1984-86, 175 different individuals were captured by rocket-netting (Table 1). Eleven recaptures included two birds each caught three times. Except for four individuals recaptured to affix or replace transmitters, intentional recaptures were avoided. Banded birds, especially subadults, often returned to bait sites. Captures per trap-day decreased ten-fold from late summer 1984 to late summer 1986 (Table 1). Although some of the poor trap success in 1986 resulted from inadequate manpower and avoiding shots at birds already banded, most was due to decreased trappability of the cranes. Trappability appeared inversely related to food supply on drawn down pools. During late summer 1984, optimal draw down conditions for netting cranes existed. Four large pools had been drawn down in late June to early July. During August and September these relatively barren flats were very attractive to cranes. In 1986, however, some pools, especially those most used by cranes, were still drawn down in their second season, and supported lush vegetation growth. Cranes therefore had many alternative foods and did not respond well to bait.

Period	Max. no. trap-nets	No. days	No. shots	No. new birds captured	No. recaptures	Captures per trap day
<b>1984</b>						
Aug.-Sept.	2	55	17	71	1	1.31
<b>1985</b>						
April	2	ND <sup>a</sup>	1	2	0	—
Aug.-Oct.	7	274	29	66	6	0.26
<b>1986</b>						
April	4	33	6	7	3	0.30
Aug.-Oct.	5	239	12	29	1	0.13
<b>Total</b>			65	175	11	

**Table 1.** Results of rocket-netting sandhill cranes on Sency, 1984-86.

<sup>a</sup>No data.

Trappability also appeared inversely related to crane reproductive success. Fall recruitment of fledged young of the year in 1984, a good year for netting cranes, was 4.7 juveniles/100 adults. During 1985 recruitment was 8.9 juveniles/100 adults. During 1986, a poor trapping year, recruitment was 11.2 juveniles/100 adults. Because production of young is related to level of environmental stress on the population, a bad year for the cranes apparently is a good year for capturing them and vice versa.

In April, birds were already dispersed on territories. In 1986 early snowmelt made netting feasible (Table 2). Birds fed mainly in the upland meadows in mornings and evenings, where they were particularly attracted to earthworms. Wetlands were flooded in April and were not practical to trap. During August to September cranes were attracted to grasshoppers Acrididae in the meadows. They fed on corn after leaving the roost and before grasshoppers became active. Most captures were made on drawn down pools. Cranes were present on drawn down pools during morning and evening, and frequently at mid day. They used pools for roosting and loafing, as well as for feeding. Use of pools was unpredictable. A site with 60 cranes one day might have none the next. Most capture attempts were made in the evening. If no shot was possible - for example, if the birds were never in position - another attempt usually could be made the next morning, because birds present during evening roosted there that night if undisturbed.

	April upland	Aug.-Oct. upland	Aug.-Oct. drawn-down pool
Morning	1	31	48
Midday	2	0	23
Evening	9	8	64
Total	12	39	135

**Table 2.** Total sandhill crane captures by season, habitat, and time of day on Sency, 1984-86. Morning = <1200, midday = 1200-1600, evening = >1600.

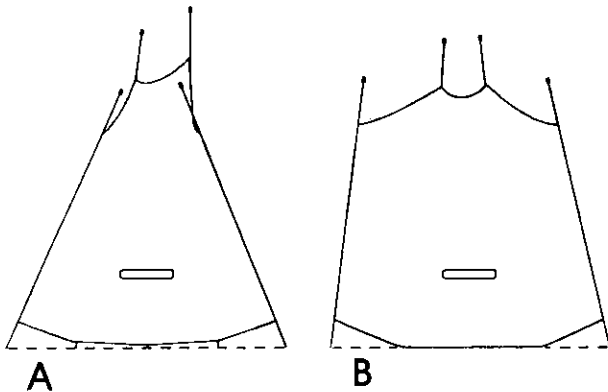
### Effects of Net Setup on Capture Success

We prefer a large, light-weight net. Most birds captured were caught under the leading edge of the net; therefore, a forward thrust dimension of 12 m is recommended to reduce escape. Anchor lines can be lengthened to increase forward thrust on narrower nets. A standard 21-kg net was acceptable, but a 32-kg net was too heavy, in terms of transport, extension, and safety to birds. An 11-kg net, the weight we preferred, usually extended fully when shot, did not slow appreciably when wet, was easy to carry to and from sites, and required only three rather than four rockets for adequate propulsion. The 11-kg net also had 40 cm<sup>2</sup> mesh rather than the 25 to 32 cm<sup>2</sup> mesh of the other nets. The larger mesh size minimized escapes because the wrists of the greater sandhills went through the mesh, and were thus held. No serious injuries resulted from this type of entrapment.

We believe we have identified the lowest vertical rocket angle to catch birds safely and still minimize escapes (with the bait pile centered 3.5 m from the net). From a sample of 24 rockets in 1986, this angle was calculated as 27.3° ± 0.28° (1 SE). The critical distance was 3.13 m ± 0.039 m (1 SE). During 1984 the rocket angle was not measured, but escape rate was low. During 1985, when more emphasis was placed on catching successful parents, the rocket angle was raised slightly to further reduce chance of injury. The

estimated angle used that year was 29 - 34°. Of 98 attempted captures, 74 were successful; the escape rate was 24.5%. In 1986 the rocket angle was lowered to the recommended 24.5° - 29.5° ( $\bar{x}$  = 27.3°). Of 42 attempted captures, 40 were successful; the escape rate was only 4.8%, and bird safety was not compromised.

The literature contains little information on the effects of forward rocket aiming on net trajectory. Dill (1969) suggested inseting the outer rockets and aiming them toward the point at which the forward corners of the net should land if the net were fully spread when it hit the ground. We found that the outer rockets, because they have less weight to pull and the entire load is on the inside, are drawn inward when all rockets are aimed straight ahead; the result is a triangle firing (Figure 3A). Inseting and directing the end rockets outward help compensate for this course alteration and result in a fuller net spread (Figure 3B). When rockets are aimed straight ahead the net contains folds that tend to trap birds that are brought down underneath. With inseting of the outer nets, the fuller net spread helps prevent escape of birds that move toward the corners when the net is shot; once down, however, the birds have a slightly better chance of escape because they can move under the net until they reach the edge. We prefer aiming all rockets straight ahead when the goal is to capture three or fewer birds, and inseting the outer rockets for larger numbers.



**Figure 3.** Deployments of the same net when (a) all rockets were aimed straight forward and (b) the outer rockets were inset 2 m and aimed outward approximately 7° (see Figure 2). This example typifies the effects of rocket positioning on net spread.

#### Casualties

Of 186 captures and recaptures, only one crane died and another sustained a debilitating wing injury as a result of netting. We know that our casualty rate has not been underestimated because 97% of our individually color-marked birds have been resighted, mostly during migration at Jasper-Pulaski Fish and Wildlife Area in Indiana, including all of those which we had any reason to suspect might have been injured. The only mortality occurred in 1984 during the only shot made at a large flock (more than 30 birds) at a flooded site. The bird appeared normal at release, but later died. The greater the number of cranes

present, the lower the probability of having all cranes in position for a safe shot. In the Central Flyway, where shots are typically made at large numbers of flocking birds, known net-associated mortalities of 7% (Wheeler and Lewis 1972), 10% (Ramakka 1979), and 15% (Tacha et al. 1981) have resulted. Our other casualty was a bird that sustained a dislocated wing that was caught under one of the net's snag lines when the shot was made. Snag lines, used to tie the skirt into the body of some older nets, should be removed from nets used to capture cranes.

#### Effects of Netting on Crane Behavior

Netting cranes just prior to or early in incubation had no effect on reproductive performance. On 18 April 1986, both adults of one pair were netted just prior to egg-laying. They hatched two chicks on 25-26 May. On 24 April the male of another pair was netted shortly after initiation of incubation. This pair hatched two chicks on 21-22 May. The male of a third pair was caught on 26 April; a nest with two eggs, though later destroyed by a predator, was found being incubated on 13 May. Distances from trap-site to nest for the above three pairs were 0.9, 0.9, and 1.4 km, respectively.

Rocket-netting did not disrupt family groupings. Parents and chicks resumed normal family structure after release, even when one of the parents escaped capture. Release of birds after dark also did not affect survival or family integrity. Fast processing time has been emphasized in some studies (for example, Melvin et al. 1983). We, on the other hand, hold the birds for whatever time is necessary to ensure that color bands and/or transmitters are securely attached. For adults with transmitters, this time is at least one-half hour. As a result we have had no transmitter losses and, to the best of our knowledge, no loss of any color bands. Holding birds for this additional time has had no effect on subsequent survival or behavior.

#### Problems With Capturing Cranes

A serious problem with capture was that during certain periods, for example late 1986, cranes were not interested in the bait. We found no solution to this problem.

Problems with rocket-netting equipment are common but are almost always related to improper handling of charges and equipment (Sharp and Smith 1986). Our netting operations were relatively free of equipment-related malfunctions. We had problems with poor net deployment caused by wet charges in late summer and autumn 1986. These problems resulted from (1) prolonged (up to a month) stay of rockets on drawn down pools without firing, and (2) use of improperly scaled charges from one of our two suppliers. We recommend twisting and doubling over the end of the bag covering the charge, and then taping the doubled end.

Our only other equipment-related problem was ground fire during April 1986. During summer and autumn trapping periods, the soil and vegetation were damp and we had no fires. In spring 1986, however, a fire resulted from every shot and holes were burned in several nets.

The major problem with capturing cranes by rocket-netting on Seney was consumption of bait by other animals, primarily Canada geese, white-tailed deer *Odocoileus virginianus*, raccoons *Procyon lotor*, and black bears *Ursus americanus*. The major bait consumers were geese, especially in September to early October, when large migratory flocks would destroy a bait pile within hours after its establishment. Geese were a problem on all drawn down pools during summer and autumn, although sometimes they acted as decoys to attract cranes to the netting sites. Deer and bears were primarily a problem on upland sites, and both, like geese, completely eliminated corn piles once they became accustomed to feeding at a site. Raccoons were a problem on drawn down pools, not primarily by depleting bait but by feeding in groups on the piles during morning and evening and thus keeping cranes from using the bait.

#### SUMMARY

Drawn down pools provided the greatest potential for

capture of sandhill cranes during August to October. Netting sites were established so that they could be checked from a remote vantage point, and blinds were located so that they could be entered without detection of the netter by cranes on the netting site.

Isolated upland meadows were good capture sites in April and August to early September. Late summer capture attempts at these sites were made by waiting in the blind before arrival of birds in early morning.

Fewer birds escaped when rockets were aimed upward at approximately 27° from the ground surface. Shots were made only when cranes were near the bait pile, which was located 3.5 m from the front of the net.

Injuries were avoided by making shots only when cranes were at least 2.5 m from the front of the folded net and had heads down. Of 186 captures and recaptures only 1 mortality and 1 serious injury resulted.

Capture success per effort expended varied greatly between late 1984 and late 1986.

#### ACKNOWLEDGMENTS

This study was funded by the U.S. Fish and Wildlife Service, Office of Endangered Species; in 1986 additional funds were provided by the Michigan Department of Natural Resources. We thank D. Frickie, Manager, and M. Anderson, Assistant Manager, Seney NWR for cooperation, support, and permission to use Refuge equipment. We especially thank J. Kesel, Refuge Biologist, for giving us our initial instruction on netting equipment, operating procedures, and safety precautions. We thank L. Schumann, U.S. Fish and Wildlife Service, and the U.S. Forest Service (East Unit, Hiawatha National Forest) for equipment loan. We are grateful to the following volunteers who offered their services as rocket net crew members: B. Applebaum, R. Fischer, M. Fisher, M. FitzGerald, C. Hansen, A. Johnston, J. Kanter, D. Kattler, M. Krywalt, D. May, G. Petersen, M. Roth, L. Row, L. Sommer, K. Vaughn, and K. Winsor.

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## CAPTURING CRANES WITH ALPHA-CHLORALOSE (AN ORAL TRANQUILIZER)

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### ABSTRACT

This paper outlines the steps needed to capture wild cranes using bait treated with the chemical compound alpha-chloralose (an oral tranquilizer). Bait sites are selected where cranes are already feeding in early morning. Cranes are then conditioned to eat untreated bait. Narcotized cranes can be captured within 1-2 hours after feeding on alpha-chloralose treated bait. Recovery time ranges from 2-48 hours. This capture technique should only be used by qualified personnel under a strictly controlled situation. In the United States the use of alpha-chloralose is restricted to investigational use in laboratory research. Scientists are cautioned to comply with all their in-country wildlife regulations before using this capture technique.

### PREBAITING

*Goal: condition the birds to fly in to your bait site early in the morning on a regular basis and to remain in this area after feeding.*

#### 1. Selecting the bait site

Select a bait site where cranes are regularly feeding.

*Do not* try to lure cranes into an area that they do not already use because they will feed and then fly off.

Choose an upland area that is open and where the cranes can be easily observed.

*NEVER* bait cranes close to a lake or a wetland because when drugged they may go into the water and drown.

There should be *NO* human activities in the area, including livestock grazing, that could frighten the birds.

If you need a blind or hide from which to observe the birds, it should be approximately 100 m away from the bait site; it should be erected > 1 week before capturing so that cranes become accustomed to it.

If cranes are accustomed to vehicles, observe them from the vehicle parked approximately 100-200 m from the site.

#### 2. Bait

Use either whole, shelled corn or shelled peanuts, or another large grain.

#### 3. Presenting the bait

With a shovel, dig five to ten small areas about 1 m apart; cranes will be attracted to the turned soil.

Put a small pile of bait *on top* of each disturbed area. You can then monitor how well they eat *and* you can more easily find your bait site.

Sprinkle the rest of the bait *near* your bait piles.

Put out bait either *late* afternoon, when the birds have left for the day/*OR* *early morning* before the birds arrive.

If many birds use the bait site and there is a lot of aggression, create one to two other bait sites each with five to ten bait piles; each bait site should be 50 m from the others.

#### 4. How often to bait

For each bait site use 2.5 - 3.0 liters of bait, creating the five to ten small areas and also scattering some of the bait nearby.

Bait every other day until birds are eating bait regularly **WITHIN 2 HOURS AFTER LEAVING THE ROOST IN THE MORNING.**

Early morning feeding on bait is *very important* later when you capture cranes with drugs because dosage rates are calculated assuming the cranes have an empty stomach when they eat.

**APPROXIMATELY 3-5 days** before capturing, bait the site every morning before the cranes arrive.

Limiting amounts of bait avoids waste and reduces the problems caused by other animals feeding on the bait.

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Limited bait gets cranes accustomed to fly directly to bait site early in the day so they will find the bait.

**BEFORE A CAPTURE ATTEMPT, MAKE SURE CRANES EAT ALL THE BAIT (2.5-3.0 LITERS) IN ONE DAY.**

#### 5. *What to watch for at bait sites*

Make sure cranes arrive early in the morning; if cranes are using the bait site only in the afternoon, *do not capture cranes there!!*

**MAKE SURE THE CRANES STAY ON THE BAIT SITE FOR 2-3 HOURS FIRST THING IN THE MORNING.**

*It is not good to select a bait site where cranes fly in and feed for only a short time and then fly to another site.*

*Do not select a bait site where cranes fly in to feed after feeding somewhere else earlier.*

Make sure cranes eat all the bait.

Make sure other grain-eating birds such as crows (corvids) and blackbirds (icterids), and mammals such as cows, mice and pigs are not coming to the site and eating. These other animals can cause serious problems on capture days.

Make sure there is no possibility of human disturbance that will frighten the birds.

Make sure birds are accustomed to the blind or the vehicle.

#### CAPTURING

**FIRST RULE: DO NOT CAPTURE CRANES WITH DRUGS ON A COLD DAY (<3 °C) OR ON A RAINY DAY BECAUSE THE ALPHA-CHLORALOSE LOWERS THE BODY TEMPERATURE OF THE CRANES.**

**SECOND RULE: ONLY CAPTURE IN THE MORNING, NEVER IN THE AFTERNOON.**

**THIRD RULE: IF CRANES HAVE NOT EATEN THE BAIT BY 2 HOURS AFTER LEAVING THE MORNING ROOST, DO NOT CAPTURE THAT DAY. INSTEAD PICK UP THE DRUGGED BAIT, TRY AGAIN ANOTHER DAY.**

#### 1. *Bait dosage per crane and how many cranes to catch*

Total bait depends on the amount of crane use on the site and the number of cranes you want to capture.

Each crane should eat approximately 140 cc bait (i.e., 1/2 cup dry measure bait).

*Do not try and catch more than 12-15 cranes per attempt; there should be a team of 3-4 people to catch cranes.*

#### 2. *What drug is used to capture*

Use alpha-chloralose (C<sub>8</sub> H<sub>11</sub> Cl<sub>3</sub> O<sub>6</sub>) - this is an oral tranquilizer. It comes in a fine white powder, and is odorless and almost tasteless.

Alpha-chloralose is available in the United States BUT CURRENTLY ITS USE IS RESTRICTED TO HIGHLY CONTROLLED EXPERIMENTS USING INVESTIGATIONAL TECHNIQUES IN LABORATORY RESEARCH.

Alpha-chloralose can be purchased from:

Fisher Scientific Headquarters  
50 Fadem Road  
Springfield, New Jersey 07081 U.S.A.  
(phone: 201-467-6400)  
cost: six 10g bottles for US\$87.90

Eastern Chemical  
P.O. Box 2500  
Smithtown, New York 11787 U.S.A.  
(phone 516-273-0900)  
cost: 1 kg for US\$100

Outside of the United States alpha-chloralose can be purchased through representatives of Fisher Scientific.

#### 3. *How much alpha-chloralose drug to mix with the bait*

Premeasure the dosage of alpha-chloralose *very carefully* on a properly calibrated triple-beam balance scale or any other highly sensitive metric scale that will measure to 0.01 g accuracy.

Find the proper dosage from Table 1 for use with whole shelled corn or shelled peanut bait. Mix the appropriate dosage of alpha-chloralose with 2840 cc bait (equals 10 dry measure cups bait). This amount will catch 20-30 cranes if feeding is normal.

If < 30 cranes are using a site, put out a portion of the batch. Calculate 140 cc (1/2 cup) treated bait per bird. YOU SHOULD NOT TRY TO CATCH MORE THAN 15 CRANES UNLESS YOU ARE EXPERIENCED WITH THE TECHNIQUE.

**IT IS BEST TO START WITH THE LOWER RECOMMENDED DOSES AND GAIN EXPERIENCE BEFORE USING HIGHER DOSES OF ALPHA-CHLORALOSE.**

Large grains are preferred bait, however, if using a small grain for bait such as rice, wheat, or barley USE A SLIGHTLY LOWER DOSAGE.

Species	Average species weight (kg)	Alpha-chloralose dosage (grams) PER 2840 cc bait
Black-crowned <i>Balearica pavonina</i>	3.63	3.2 - 3.6
Grey-crowned <i>Balearica regulorum</i>	3.50	3.2 - 3.6
Stanley <i>Anthropoides paradisea</i>	5.15	4.4 - 5.0
Demoiselle <i>Anthropoides virgo</i>	2.40	2.1 - 2.4
Wattled <i>Buggeranus carunculatus</i>	7.90	6.8 - 7.7
Brolga <i>Grus rubicundus</i>	6.02	5.2 - 5.9
Eastern Sarus <i>Grus antigone sharpii</i>	6.40	5.6 - 6.3
Indian Sarus <i>Grus antigone antigone</i>	7.40	6.4 - 7.3
White-naped <i>Grus vipio</i>	5.63	4.9 - 5.5
Sandhill <i>Grus canadensis rowani</i>	3.95	3.5 - 3.8
Sandhill <i>Grus c. canadensis</i>	3.46	3.0 - 3.4
Sandhill <i>Grus c. tabida</i>	4.70	4.0 - 4.5
Sandhill <i>Grus c. pratensis</i>	4.30	4.0 - 4.5
Black-necked <i>Grus nigricollis</i>	5.93	5.2 - 5.8
Common <i>Grus grus grus</i>	5.27	4.6 - 5.2
Common <i>Grus g. lilfordi</i>	4.30	3.8 - 4.2
Hooded <i>Grus monacha</i>	3.74	3.3 - 3.7

**Table 1.** Recommended alpha-chloralose dosage (grams) for 2840 cc bait<sup>a</sup>.

<sup>a</sup>For use with whole shelled corn or shelled peanut bait. If using a small grain for bait such as rice, wheat, or barley USE A SLIGHTLY LOWER DOSAGE.

Remember: premeasure your alpha-chloralose drug dosage CAREFULLY. Too much will overdose the cranes, and they can die!!!

Note: the recommended dosages are based on the assumption that the birds are feeding well, that there is no aggression from other cranes and no other food items available to distract the cranes.

#### 4. Temperature and alpha-chloralose dosage

Cold weather (< 3°C) often causes birds to eat more and eat faster, thus increasing the consumption and the effect of the drug.

Cold weather also increases the tranquilizing effect of the drug and cranes are more susceptible to hypothermia.

IT IS BEST NOT TO CAPTURE IN COLD WEATHER. IF CAPTURING IN COLD WEATHER CANNOT BE AVOIDED, HOWEVER, REDUCE SLIGHTLY THE DOSAGE OF ALPHA-CHLORALOSE USED ON THE BAIT.

#### 5. Mixing the alpha-chloralose and the bait for capture

If the bait is whole, shelled corn, FIRST sift the corn to get rid of small pieces. Sifting the corn prevents small grain-eating birds, crows (corvids), and blackbirds (icterids) from eating the drugged bait and attracting raptors and other predators that will harass or distract the cranes. Small drugged birds can also frighten the cranes.

In a bucket, wet the bait with water for 1 minute.

Drain off all excess water.

Sprinkle the premeasured alpha-chloralose drug on the bait while stirring (folding) with a spoon.

*Do not* have free water in the bucket with the bait. Water dilutes the dosage.

NOTE: Prepare the bait with alpha-chloralose < 1 hour before putting it out on the bait site; otherwise the drug will fall off as it dries.

#### 6. At the bait site on capture day

REMEMBER: *DO NOT* CAPTURE CRANES ON A COLD DAY (< 3°C) OR RAINY DAY.

REMEMBER: *DO NOT* BAIT OR CAPTURE CRANES CLOSE TO A LAKE OR WETLAND.

Clear the bait site of any untreated bait before presenting treated bait.

BEFORE THE BIRDS ARRIVE, put the drugged alpha-chloralose bait IN PILES of approximately 140 cc *only* on the five to ten small areas. *DO NOT* SCATTER THE BAIT.

*DRUG AT ONE SITE ONLY.* If you have nearby one or more additional bait sites you have maintained because of too many cranes and previous problems with aggression, REMEMBER to put 2.5-3.0 liters of regular, untreated bait *WITH NO ALPHA-CHLORALOSE* on these separate bait sites; this will discourage aggression between narcotized birds and birds that did not consume drugged bait.

Have your nets and capture equipment ready.

Make sure there are no humans nearby or domestic animals which might disturb the cranes.

### 7. How to know when a crane is drugged and how long to wait before capturing

Cranes eating drugged bait show evidence of narcosis (sleepiness) within 20 minutes to 1.5 hours.

Usually cranes stop feeding after 30-60 minutes and will begin preening; they may fall asleep standing up, or will fall down several times, or will walk aimlessly.

All humans should wait *out of sight* for 1-2 hours after the birds begin feeding on the drugged bait. This will allow the alpha-chloralose time to affect the cranes.

**DO NOT WAIT MUCH MORE THAN 2 HOURS TO BEGIN CATCHING THE CRANES AS THE DRUG EFFECTS WEAR OFF.**

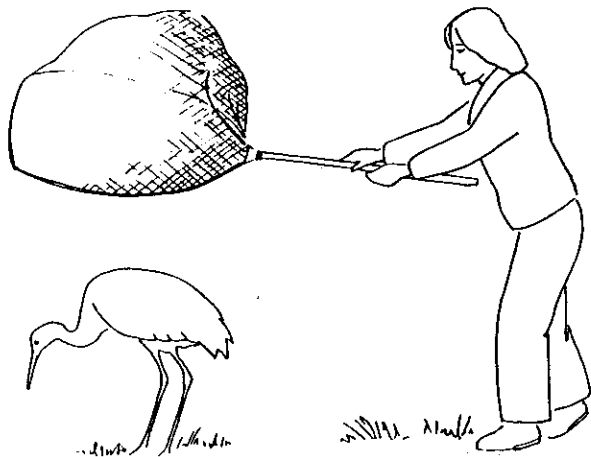
After 1 to 2 hours (usually 2 hours) begin to pick up the drugged cranes.

If a crane does not show any symptoms of narcosis and flies off a long distance 45 minutes or so after feeding the crane probably did not eat enough drugged bait and can be assumed to recover.

### 8. Capturing the cranes

Anyone catching a crane should wear safety glasses.

Drugged cranes should be approached *quietly* and *slowly* from *behind* with a **LONG-HANDLED NET** (Figure 1).



**Figure 1.** Drugged cranes should be approached quietly and slowly from behind with a long-handle net.

**FIRST** capture any bird in danger of collapsing in water and cranes that appear to be **LEAST** tranquilized - approach them slowly and allow them to walk away from other tranquilized cranes because if these cranes are **frightened** they may disturb additional, lightly tranquilized cranes that otherwise could be caught.

Some cranes that are adequately tranquilized for capture may walk aimlessly, sometimes in circles, these birds *can* and *should* be captured. Do not assume they are alert and safe from predators.

Be careful not to frighten cranes.

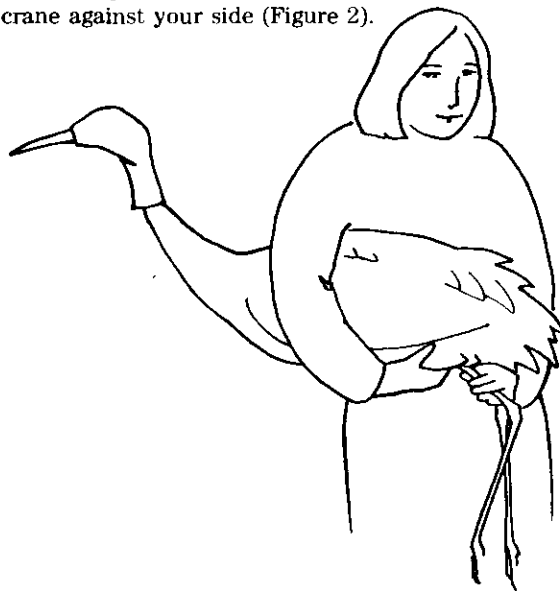
Be careful not to mishandle cranes.

If a drugged crane flies from the area, locate and capture the crane as quickly as possible. Drugged cranes are vulnerable to both predator attacks and attacks by cranes that have not eaten any drugged bait.

On the capture site sedated cranes may be attacked by fresh, underdrugged late arrivals. Such late arrivals can often be driven off by a slight disturbance. **BUT** be careful not to flush drugged cranes.

### 9. How to hold the crane

After catching the crane, fold the wings against the crane's body, wrap one arm around the trunk, and position the crane against your side (Figure 2).



**Figure 2.** Captured cranes should be removed from the bait site immediately. Fold the wings against the crane's body, wrap one arm around the trunk, and position the crane against your side. Legs should be grasped above the tibio-tarsal joint. Hood the crane to minimize stress and movement.

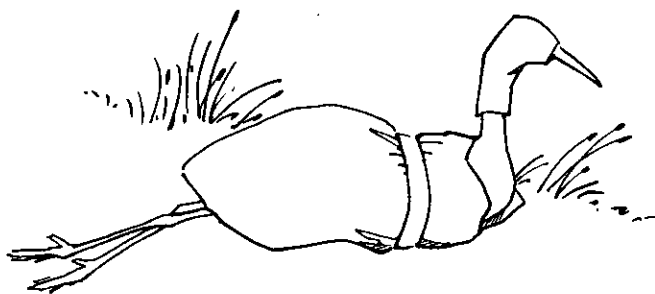
The crane's head and neck should face what is behind you; this prevents the crane from striking your face.

Grab legs *at the tibio-tarsal joint* (ankle, *not the foot*) with the free hand.

**DO NOT RESTRAIN CRANE LEGS CLOSE TO THE TOES, THIS OFTEN CAUSES PERMANENT CRIPPLING TO THE CRANES.**

Cover the crane's head with a sock or hood, being careful not to inhibit breathing; the cover will quiet the crane.

Put the crane in a sack or other restraining device but leave the head and neck outside the sack; secure the wings against the crane's body by wrapping a light fabric, duct tape, or velcro strips around the outside of the sack (Figure 3).



**Figure 3.** Temporarily restrain the crane using a sack or other device secured around the trunk. Secure the legs together above the tibio-tarsal joints with a light fabric, tape, or velcro strips. **Do not** restrain cranes for long periods of time.

Secure legs *above* the tibio-tarsal joints - a light fabric, surgical tape, duct tape, or velcro strips can be used to hold legs together.

KEEP CRANES WARM IF WEATHER IS COLD.

KEEP CRANES IN THE SHADE IF WEATHER IS WARM.

IMMEDIATELY AFTER ALL DRUGGED CRANES ARE CAPTURED, MOVE THEM TO THE SITE WHERE YOU WILL BAND THEM AND ALLOW THEM TO RECOVER.

#### 10. *Before leaving the bait site*

FIRST, IT IS VERY IMPORTANT TO PICK UP ANY REMAINING DRUGGED BAIT SO THAT OTHER CRANES OR ANIMALS CANNOT EAT DRUGGED BAIT.

SECOND, *IMMEDIATELY* PUT OUT FRESH, UNTREATED BAIT (*NO* ALPHA-CHLORALOSE) in case you overlooked any drugged bait.

#### HANDLING CAPTURED CRANES AND RECOVERY TIMES

##### 1. *Obvious effects of alpha-chloralose*

Alpha-chloralose is a general depressant.

Alpha-chloralose reduces body temperature.

Alpha-chloralose reduces respiration.

Alpha-chloralose lowers heartbeat.

Alpha-chloralose causes increased mucous production.

Alpha-chloralose causes cranes to drool and gurgle.

Alpha-chloralose causes water to discharge from eyes.

Alpha-chloralose causes loose, runny feces.

#### 2. *Banding and weighing.*

Minimize the physical exertion of the bird.

Remove the sack, but leave the hood on the crane to minimize stress. Make sure the hood does not impede breathing.

Weigh, measure, and band the bird while it lies on its sternum.

Watch for stress.

Always maintain control of the crane's legs and upper neck.

Watch your safety - drugged birds are *AS STRONG AND AS DANGEROUS* as normal birds. They will use their feet and beak!!! Wear your safety glasses!

After banding and weighing, remove hood and release the bird into holding cage until it has recovered from drugs.

#### 3. *Holding cage/or tent*

When possible, the holding cage should be close to the capture site.

Cage or tent should be high enough for birds to stand erect but not so tall that they will fly and injure themselves.

Cage floor should be dirt or sand, and *not* be smooth plastic, wood, or cement.

The sides of the cage should be covered to reduce stress.

Cage roof should be covered on hot, sunny days.

Cage should be predator proof.

Keep cranes dry and warm if weather is rainy or cold; keep them in the shade if weather is hot and sunny; remember that alpha-chloralose lowers the body temperature.

Initially, **DO NOT** put water in the cage with the cranes because drinking will speed up drug absorption and can

cause an overdose; also a drugged crane may inadvertently drown if its head falls in the water bowl.

If cranes are held for > 8 hours/and or held overnight, you can put fresh water in the cage but only in a small, shallow container.

*Keep the public away from the cranes*

*DO NOT CONFINE CRANES WHERE OTHER DOMESTIC OR CAPTIVE BIRDS HAVE BEEN OR ARE PRESENTLY CONFINED BECAUSE* domestic and captive birds frequently harbor diseases that wild cranes have not previously been exposed to and to which the *wild cranes could be very susceptible*.

If a cage is used repeatedly, the ground or floor should be cleaned or disinfected routinely after every capture event.

#### 4. *Recovery from drug effects and releasing the cranes*

Cranes will be incapacitated anywhere from 2-48 hours; do not release them until they have completely recovered.

Recovery time varies depending on amount of bait consumption, general condition of the individual, and ambient temperature.

A crane is probably recovered if it holds its head up normally and walks alertly and briskly with no shaking or quivering in legs, vocalizes when you approach it, and attempts to defend itself or acts aggressively.

*DO NOT RELEASE RECOVERED CRANES < 1 HOUR BEFORE SUNSET AS CRANES NEED TIME TO REORIENT THEMSELVES BEFORE ROOSTING.*

WHEN IN DOUBT, HOLD CRANES OVERNIGHT.

CRANES SHOULD BE RELEASED AT THE BAIT SITE WHERE THEY WERE CAUGHT, OR DIRECTLY FROM THE HOLDING CAGE *ONLY IF IT IS VERY CLOSE TO THE BAIT SITE*.

#### 5. *First aid for heavily sedated cranes*

Heavily sedated cranes will lie motionless in unnatural positions (on the back or side) even 1 hour after capture. Arrange them in a natural position with the head pointing down.

These heavily sedated birds should especially be protected against cold by wrapping them in blankets or keeping them close to heat.

Keep heavily sedated birds *DRY*.

Keep heavily sedated birds head up if possible.

Periodically, a heavily sedated crane should be held up and shaken or stimulated by manipulating its legs and wings (BE GENTLE!!).

Heavily sedated cranes often regurgitate bait or mucous - BEWARE OF ASPIRATION (BREATHING INTO THE LUNGS THE BAIT OR MUCOUS)—TRY TO CLEAR MOUTH AND THROAT BY HOLDING CRANE UP, WITH NECK AND HEAD DOWN AND MOUTH OPEN - gravity will do the rest.

On the capture site sedated cranes may be attacked by fresh, underdrugged late arrivals. Such late arrivals can often be driven off by a slight disturbance. BUT be careful not to flush drugged cranes.

Do not assume drugged birds can defend themselves.

GOOD LUCK AND REMEMBER SAFETY FOR BOTH THE CRANES AND YOU COMES FIRST!!!!

#### ACKNOWLEDGMENTS

I especially thank Steve Nesbitt of the Florida Game and Fresh Water Fish Commission for his valuable comments and suggestions in the preparation of this manuscript, and for initially exposing me to the alpha-chloralose trapping technique. I also thank my cousin Nona Schaffner and the many volunteers who helped me capture Florida sandhill cranes *Grus canadensis pratensis* on the Kissimmee Prairie, Florida during 1985. The ranchers on the Kissimmee Prairie provided generous access to their lands in order to bait and capture the cranes. Susan Lindstadt, formerly of Malheur National Wildlife Refuge, drew the figures. This study was supported by the University of Florida's School of Forest Resources and Conservation, Florida Game and Fresh Water Fish Commission, National Audubon Society, U.S. Fish and Wildlife Service, Cooperative Fish and Wildlife Research Unit, the Henry and Kathryn Mills Charity Foundation, and the Florida Chapter of the Sierra Club. I thank the International Crane Foundation, both the International Programs in the Institute for Food and Agricultural Science and the Graduate School, University of Florida for travel grants to attend this conference.

## Appendix I. Equipment needed to capture cranes.

*necessary equipment:*

small shovel and/or spade  
 bait: whole shelled corn, shelled peanuts, or  
   other large grain  
 water (to wet grain)  
 alpha-chloralose (premeasured)  
 bucket and spoon  
 binoculars and telescope  
 watch  
 safety glasses for all people handling cranes  
 long-handled nets (3-4)  
 sacks or other restraining devices to hold cranes  
 soft cloth, duct tape, gauze, elastic leg wrapping or  
   velcro to tie legs, and to tie wings against torso  
 socks/or other kind of hood to cover crane heads  
 holding cage: tent or netted cage - sides covered, floor  
   not smooth  
 scale (accurate to 0.01 g) to measure alpha-chloralose  
 scale (accurate to 0.1 g) to weigh cranes  
 rope for scale (or means to hang scale for weighing  
   cranes), and for tent or tarps  
 data forms and color-code sheets  
 banding permits  
 banding box:  
   bands - color and aluminum  
   pvc cleaner and pvc glue OR rubber cement  
   cotton swabs  
   pocket knife  
   pliers  
   file  
   scissors  
   wire cutters (that will cut plastic bands too)  
   razor blades  
   calipers  
   ruler  
   hydrogen peroxide  
   coagulant (ferric subsulfate solution) for cranes  
   first aid instructions  
 first aid box  
 topical ointment

*optional equipment:*

2-way radios  
 chairs  
 blankets for cranes (if < 3°C)

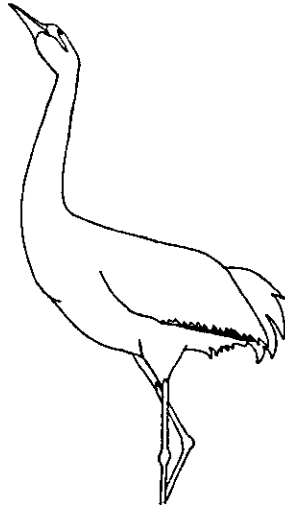
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CHAPTER 8  
EUROPE





## CRANES IN FINLAND

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### ABSTRACT

The size of the common crane *Grus grus* population in Finland is estimated to be 10,000-20,000 individuals. The population is expected to diminish because of the drainage of nesting places. The autumn percentage of young birds in the flocks is 8-9%, a strikingly low value. There seem to be three main migration routes, with birds of the westernmost route forming a subpopulation that migrates earlier in spring and later in autumn.

### INTRODUCTION

Finland forms part of the nesting area of the common crane. Study of the population is difficult because crane pairs are found in all parts of the country, often in inaccessible places; also, migration seasons are long and migrating flocks can be seen everywhere, especially in autumn. Crane study is coordinated by the Finnish Working Group on Cranes, a voluntary organization.

The aim of this paper is to give a short review of the present state of knowledge. In the last section, some recent discoveries will be summarized.

### SPRING MIGRATION

There are perhaps three main routes or migration channels, which partly overlap. The central route of the spring migration is best known (Rinne 1974, 1983) and is so regular that characteristic features can easily be documented. More than 50% of the observations are made during 26-30 April, often during a mass migration. Very seldom are mass migrations observed before 15 April or after 2 May. Intense migration before 20 April indicates a warm spring. Usually migration occurs between 1100 and 1400 hours. Night migration has never been observed.

The axis of this migration channel lies about 10 km west of Helsinki, with the flocks deviating from this line because of the wind: on average, an easterly wind of 1 m/s causes a deviation of 6 km westward.

The western migration route is 100-200 km west of Helsinki. This migration is clearly earlier, and may be completed before 15 April. The migration direction, as nearly everywhere in Finland, is northward. No migration occurs from the west over the Baltic or Aland Islands.

An eastern migration channel is found near the eastern boundary of Finland. Because of the northerly migration direction, birds in this channel have come from the Soviet Union, thus crossing the international boundary. Farther north, some of them once again cross the boundary and continue to nesting areas in the Soviet Union.

### AUTUMN MIGRATION

Autumn migration is much more scattered, beginning in August and finishing before the end of October. It is not well documented in the literature. According to ringing results, the migration is directed toward the south, for example, to Hungary (Karlin 1985).

### ROOSTING PLACES

In Finland, there are no roosting places comparable to those in the southern parts of the migration route. The best known place is on the western coast, near the town of Vaasa, with maximal numbers up to 1,500 individuals. The cranes are known to cause damage here to agriculture, sometimes the total destruction of fields of *Brassica pekinensis*. A peculiar feature is that cranes sometimes roost overnight on the outermost islets in the sea, possibly because bad weather inhibits morning or evening flights over the water.

### NESTING AREAS

Most commonly the crane is found in the marshy lands of the north and west. In the south, pairs are found on lakes and bays of the sea. These kinds of habitats have been occupied in increasing numbers. North of the forest boundary the crane is rare.

### POPULATION SIZE AND SUBPOPULATIONS

Merikallio (1958) estimated the number of cranes as up to 17,000. He used the method of line transects. Rinne (1983) estimated the random error limits in Merikallio to be  $17,000 \pm 5,500$ . The systematic error is not known: the result may or may not include non-nesting birds. Nesting pairs were estimated at 7,000-9,000 cranes (Karlin 1985). Total numbers of cranes observed during spring migration are at least 12,000 (Koskimies 1983) and 13,500 (Rinne 1983). These figures include all birds.

The very early migration along the westernmost route suggests that this migration group forms in fact a small separate subpopulation that differs from other populations in the west (in Sweden) and in the east. In Rinne (1983), the size of the western, central and eastern populations was estimated to be 3,700, 6,300 and 2,500, respectively. The number of birds migrating later in May was estimated to be roughly 1,000 individuals. They may be non-nesting birds.

#### THE FUTURE OF THE CRANE IN FINLAND

The rapid drainage of marshy lands threatens the crane population. Hölsä (1981) studied this problem in southeastern Finland, where the number of nesting cranes was 100 pairs. Assuming that the cranes do not find new biotopes, or that the size of the breeding territory is not reduced, the number of pairs will be 40 at the end of the century. This decline is due to the loss of nesting places, a loss that can be estimated according to present plans. These results may well describe the situation throughout Finland.

Indications of decline have been ambiguous. In some places a clear decrease in numbers has been reported, while in others no change has been observed (Hildén and Koskimies 1984). Migration statistics have remained the same. In 1981, however, a mysterious increase was observed both in the western and central migration routes. The number of observed migrants was 21,500 instead of the normal 13,500. This near doubling of numbers cannot yet be explained.

#### NEW DISCOVERIES

Ralf Rikberg (pers. comm.) observed 3,809 autumn cranes during 1983-85 in the vicinity of Porvoo and found that only 8.5% were young birds. In Southern Karelia, the number of young birds was 8.1% (Jantunen et al. 1985). Such statistics are puzzling. In Estonia, the corresponding number is 13.5% (Keskpaik and Rinne 1986) and in the wintering area of Spain, 10-15% (Alonso et al. 1984). Productivity in Finland seems to be low. But how can the large autumn numbers of young birds observed in Estonia be explained when many of the birds there originate in Finland?

By the end of September 1986, there were no migrating or resting cranes between the towns of Helsinki and Hanko. Suddenly on the afternoon of 4 October, however, some hundred migrating cranes were seen. A call to Vaasa (T. Lukkarinen, pers. comm.) provided information that a number of the birds in that roosting area had left that very day. Thus, for the first time, a long distance movement of the western subpopulation was followed. We now believe that all birds of the Vaasa roosting area belong to the western subpopulation. We also know that at least a part of that population migrates late in autumn, a fact suggested by previous field observations. Supportive evidence for both the earlier timing of the spring migration and for a separate subpopulation has thus been found.

Vilju Lilleleht (pers. comm.) claimed that mass migrations in spring do not start from Matsalu Bay or from similar places in Estonia. Finnish ornithologists are now considering the possibility that cranes that so regularly arrive on Finland's south coast at 1100 hours have arrived there from some unknown sites south of Estonia.

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## PHENOLOGICAL METHOD IN COMMON CRANE MIGRATION STUDIES

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### ABSTRACT

A method for studying the migration phenology of the common crane *Grus grus* is described. On the basis of qualitative arrival and departure curves and the qualitative migration wave, standard time parameters have been deduced that may be used to characterize the spring (and autumn) migration of cranes.

### INTRODUCTION

We have several methods of analyzing phenological data (Middendorff 1855; Herman 1905; Beklovà et al. 1983). The traditional method of isochrones, proposed by A.T. von Middendorff in 1855 has been used up to the present time (Schüz 1971; Haartman and Söderholm-Tana 1983). The use of isochrone maps is justified if a phenological network covers vast areas. Only in that case can a number of aspects of migration be established.

This paper introduces a method that allows description of the general aspects of migration phenology of the common crane in the case of limited study areas (local phenological networks; see Keskpaik 1983).

### ESTONIAN PHENOLOGICAL DATA ON THE COMMON CRANE

The ornithophenological network set up in 1922 in Estonia has been functioning up to the present time. Until 1963, observers recorded only first arrivals (in spring) and last departures (in autumn) of the cranes. Since 1964 more detailed observations of cranes have been reported. Observers of the phenological network record all crane flocks and provide information about location, date and time, number of birds, activity, flight directions, etc. The common crane is a well observed bird and a large body of data on its arrival and departure has been collected.

This study will only examine spring phenological data collected in Estonia in the period 1978-1986. The number of observers covering 45,100 km<sup>2</sup> territory of Estonia was about 200 during that period. The number of observed common cranes totaled 52,500 individuals, or about 5,800 individuals every spring.

### PHENOLOGY OF SPRING MIGRATION OF CRANES

Estonia is situated in the reproduction range of the common crane. Therefore, in Estonia the cranes are divided into local, transit, and overstepping birds. Every

spring the local cranes arrive and stay, but the transit and overstepping ones arrive and then depart. These aspects of migration may be characterized by the arrival and departure curves and by the migration wave.

Traditional phenological observations (recording of the first arrivals in spring) do not enable description of all the above mentioned aspects of migration. It is also necessary to register the last migrating flocks in spring. We have this information for Estonia during the years of the study period.

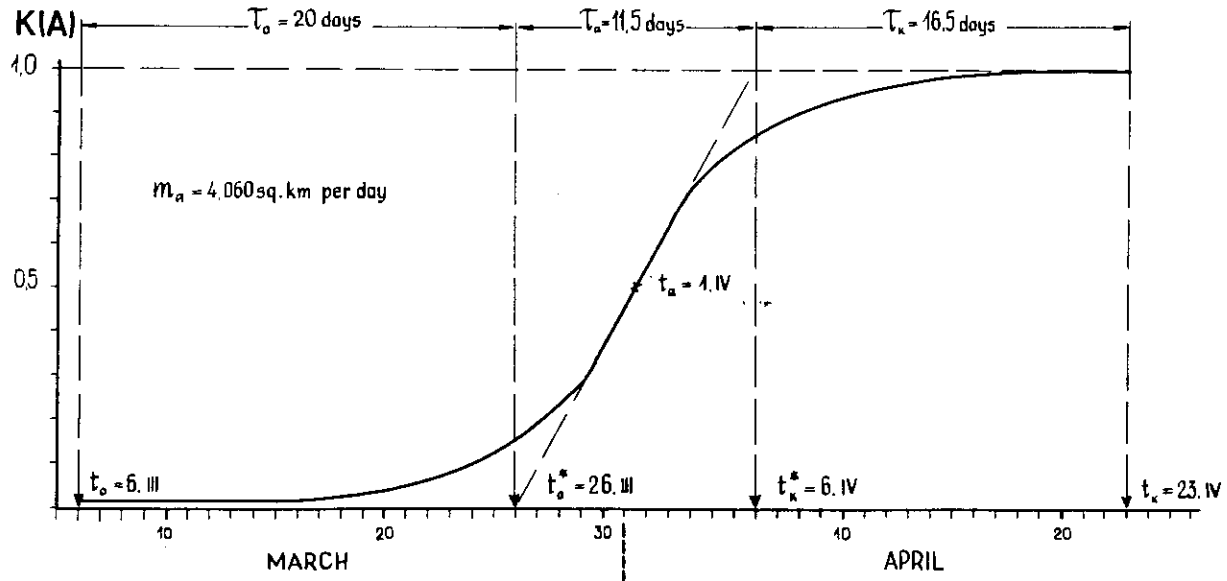
#### Spring Arrival of Cranes

The arrival of the cranes in Estonia is interpreted as a process of covering the research area with cranes. In order to study this process it is necessary to divide Estonia into equal parts unit squares (we use 50 × 50 km UTM squares) in each of which the arrival of cranes is recorded. As soon as the **first arrival** is recorded in a given square, that square is considered to be covered by the common crane. The degree of the coverage of Estonia as a whole equals the degree of the arrival of cranes at a given moment of time. This can be expressed by the following simple formula:

$$K(A) = \frac{n}{N} \quad (1)$$

where  $K(A)$  = arrival degree,  $n$  = number of unit squares covered at a given time, and  $N$  = total number of unit squares.

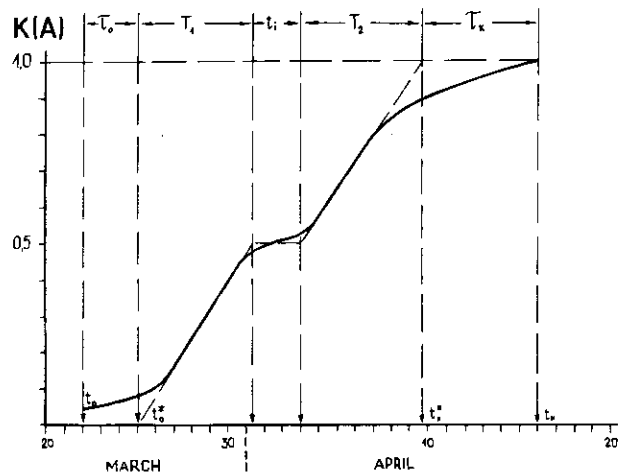
Thus, the spring arrival of cranes is characterized as an increase of  $K(A)$  from 0 to 1. If  $K(A) = 1$ , the arrival of cranes in Estonia is completed (100% coverage). Such an interpretation makes it possible to describe the phenology of spring migration of cranes by a **qualitative arrival curve** (Figure 1). This curve is figurative and makes it possible to establish standard time parameters for the migration phenology and arrival rate of cranes. Figure 1 presents the standard year curve for the period



**Figure 1.** Qualitative spring arrival curve of the common crane for the period 1978-1986 in Estonia.  $K(A)$  = arrival degree;  $T_o, T_k$  = time lags;  $T_a$  = period of maximum arrival rate;  $m_a$  = arrival rate;  $t_o, t_k$  = real initial and final moments of arrival;  $t_o^*, t_k^*$  = corresponding general moments;  $t_a$  = median time moment of arrival.

1978-1986 for the common crane in Estonia with generalized time parameters and the corresponding numerical values.

The qualitative arrival curves for different years are varied and seldom S-shaped. These variabilities depend upon the weather conditions during the spring migration. The influence of weather conditions on the arrival and departure may be analyzed by generalized time parameters and by the configuration of the curve (Figure 2).



**Figure 2.** The influence of weather conditions on the arrival of the common crane in 1982.  $t_1$  = interruption of the arrival;  $T_1, T_2$  = periods of maximum arrival rates. For other symbols, see Figure 1.

### Spring Departure of Cranes

The departure of the cranes in spring can be regarded as a gradual vacating of Estonia. Before the vacating begins, Estonia is considered to be covered by cranes. Using the **last observations** (last departures) of migrating cranes in the unit squares, it is possible to deduce the departure degree by applying the following formula:

$$K(D) = \frac{n^X}{N} \quad (2)$$

where  $K(D)$  = departure,  $n^X$  = number of RA unit squares vacated at a given time, and  $N$  = total number of RA unit squares.

Thus, the spring departure of cranes is characterized by the decrease of  $K(D)$  from 1 to 0. Such an interpretation makes it possible to describe the departure aspect in spring migration phenology by a *qualitative departure curve*. Figure 3 presents the curve for the period 1978-1986 for the common crane in Estonia with corresponding generalized time parameters and values.

### Spring Migration Wave of Cranes

The transit migration and stopovers of cranes in Estonia can be regarded as an arrival and a departure taking place sequentially. Consequently, on the basis of the formulas (1) and (2) we can construct the qualitative migration wave which is an integral representation of the spring migration of cranes (Figure 4A).

A migration wave of cranes may be divided into three phases: inflow (arrival), steady state, and outflow (departure). All these phases can be analyzed separately by the time parameters, and rates can be determined for

the inflow and outflow (see also Figures 1 and 3). In the steady state phase the migrating cranes are observed all over Estonia. An important characteristic of this wave is the **median duration** of the spring migration  $T(M)$ .

Figure 4B shows the cumulative curve of the spring migration (i.e., the percentage of cranes observed on or before each date over the years 1978-1986). The period of intensive migration overlaps with  $T(M)$ .

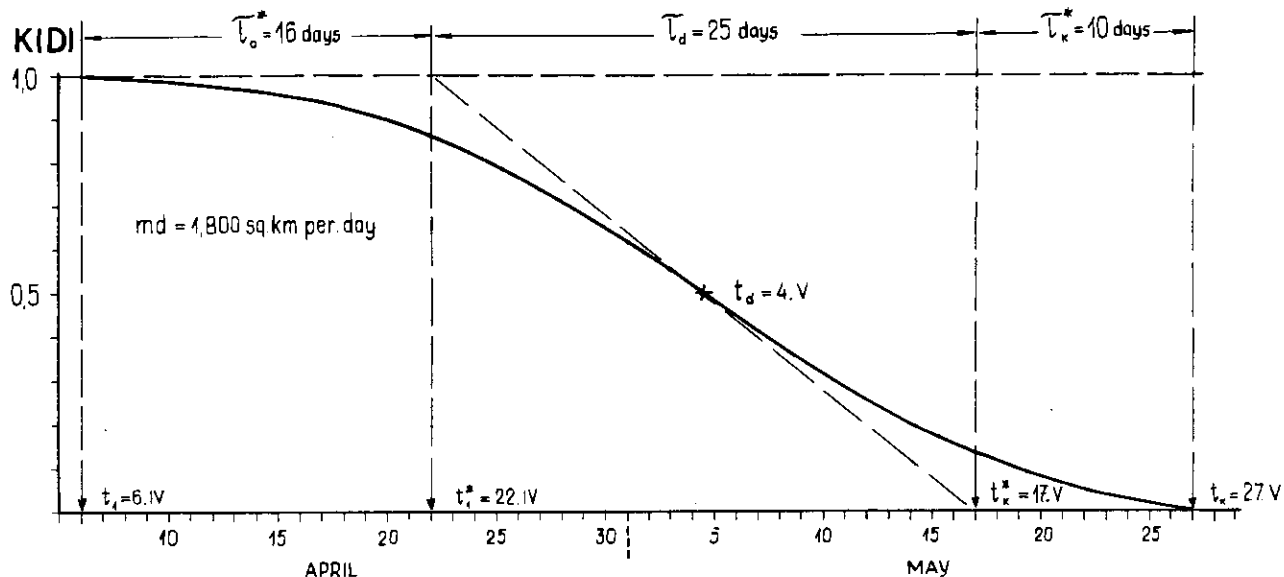
**FINAL REMARKS**

Using the formulas (1) and (2), it is possible to deduce

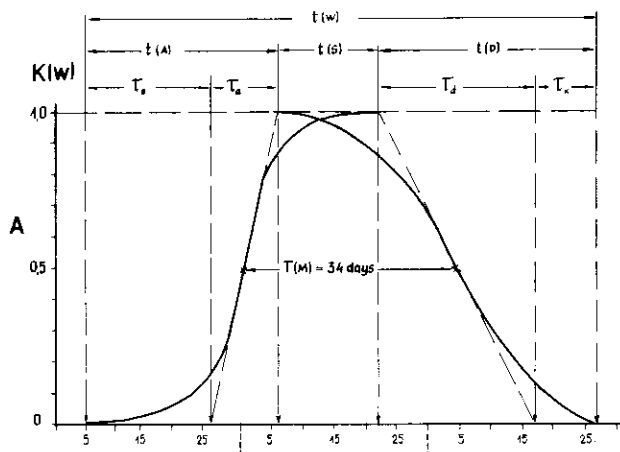
the qualitative autumnal arrival and departure curves and the autumnal migration wave.

The qualitative spring arrival and qualitative autumnal departure curves delimit the **summer presence** of common cranes in research area, which may be expressed by the following standard time parameters: real maximum and minimum presence times, corresponding general values and median presence time.

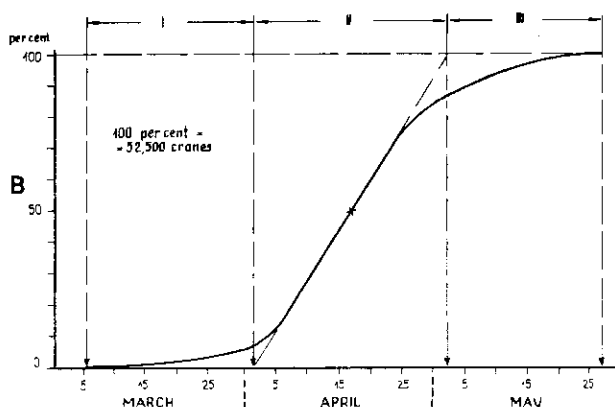
In this paper, the research area is arbitrarily divided into  $50 \times 50$  km UTM squares. The phenological method can also be used in the case of natural units i.e., territory or home range).



**Figure 3.** Qualitative spring departure curve of the common crane for the period 1978-1986 in Estonia.  $K(D)$  = departure degree;  $T_o^*$ ,  $T_k^*$  = time lags;  $T_d$  = period of maximum departure rate;  $m_d$  = departure rate;  $t_i$ ,  $t_k$  = real initial and final moments of departure;  $t_r^*$ ,  $t_k^*$  = corresponding general moments;  $t_d$  = median time moment of departure.



**Figure 4.** (A) Spring migration wave of the common crane for the period 1978-1986 in Estonia.  $t(W)$  = duration of migration wave;  $t(A)$  = arrival phase;  $t(S)$  = steady state phase;  $t(D)$  = departure phase;  $T_a$ ,  $T_d$  = periods of maximum arrival and departure rates;  $T_o$ ,  $T_k$  = time lags.  $T(M)$  = median duration of the spring migration wave.



(B) The cumulative spring migration curve of the common crane for 1978-1986; the period of intensive migration (II period) and the  $T(M)$  overlap.

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# THE COMMON CRANE IN THE GERMAN DEMOCRATIC REPUBLIC

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## ABSTRACT

In the German Democratic Republic (GDR) are 1,100 breeding pairs of common cranes *Grus grus*. The ratio between breeding and nonbreeding birds is approximately 1:1. Summering cranes - up to 200 birds together - stay at 56 sites. All cranes gather at 30 places, up to 400 at a site. Most of these find resting places during migration. Along the Baltic Sea coast rest 20-30,000 cranes; at inland sites, up to 15,000. In autumn 1985, at least 46,000 cranes used the western migration route through GDR. Within 10 districts ( $\bar{x} = 8,656 \pm 3,093 \text{ km}^2$ ) correlations were estimated as follows: breeding pairs to summering birds,  $r = 0.947$ ; breeding pairs to gathering cranes,  $r = 0.930$ ; summering to gathering birds,  $r = 0.917$ ; and gathering to resting cranes,  $r = 0.026$ . These figures reveal the close geographic connections among the first three groups. The reproduction parameters include clutch size ( $\bar{x} = 1.97$  eggs), hatching results (70.7% of all eggs, with 87.4% for successful pairs), brood size after hatching ( $\bar{x} = 1.89$  juveniles) and after rearing ( $\bar{x} = 1.37-1.42$ ); and reared juveniles of all pairs ( $\bar{x} = 1.09$  juveniles,  $n = 1517$  pairs). The variation coefficients between years and districts are low for the reared juveniles of successful pairs (4.2-8.5%), but high for the portion of pairs without success (24.9-32.5%). The share of juveniles in the Central European population amounts to 14-16%, and in the Scandinavian population, 11-13%. The high reproduction rate in Central Europe coincides with increasing breeding density. This paper is also concerned with the main migration routes with their various resting places, as well with the summering and wintering of the common crane in Central Europe. The common crane, along with its breeding and roosting sites, is completely protected as an endangered species in GDR.

## INTRODUCTION

This paper deals with a territory in Central Europe which forms the southwest boundary of the distribution area of the common crane. With a single exception, this area borders the Elbe River in the GDR.

## BREEDING AND REARING RESULTS

Northeast of the Elbe River exists a breeding density of between 0.14 and 9.03 ( $\bar{x} = 1.88$ ) pairs per 100 km<sup>2</sup> in the various districts. The northern and western adjacent regions, formerly deserted, have been repopulated step by step. Within the distribution area, for more than a decade, an increase in breeding density — in several places up to 5-8 nests per 10 km<sup>2</sup> — has been observed. This development has been coupled with nesting in small ponds in forests and recently even in fields. At present 470 nest sites are distributed as follows:

- 2.6% - low swamps connected with small streams
- 7.2% - eutrophic peat cuts
- 9.6% - swamps in pine forests
- 14.9% - eutrophic ponds and meadows
- 26.2% - eutrophic shores of lakes
- 39.5% - swamps in deciduous and mixed forests.

In 1977-79 it was estimated that the GDR had not more than 684 nests. But in 1985-86 nearly 1,100 breeding pairs were discovered (perhaps partly due to more intensive observation!). Together with immature and nonbreeding birds, the crane population totals about 4,500.

Numerous pairs were observed in the district of Schwerin between 1977 and 1986; 263 clutches had an average of 1.97 eggs, with two eggs in 93% of the clutches. For 133 clutches, breeding success was as follows:

- 13.5% were destroyed
- 15.8% were abandoned due to disturbances
- 70.7% consisted of hatched eggs.

The hatching of 181 eggs found at the end of the breeding period amounted to 87.4%. The rest were infertile, or the young had died or got stuck. Thus, the successful pairs had 1.89 juveniles (juv.).

The loss of juv. in the following months reduced the relative number of families with two offspring and increased the number with one. After fledging in July and later, 173 successful pairs reared 1.37 juv., and 38.7% of the families had two juv. The rearing loss was nearly 0.5 juv. per pair, or 27% of all hatched chicks.

The results were obtained for 1,517 pairs with breeding trials from three larger districts including about 25,000 km<sup>2</sup>

(Table 1). These results are similar to the those mentioned above. The pairs without breeding success had a high variation coefficient for different years ( $s\% = 31.8$ ). But in pairs with success, the variation coefficient for the number of juv. remained low ( $s\% = 4.2$ ). Table 2 points to the fact that besides the influence of years, the geographical conditions (districts) influence strikingly the share of unsuccessful pairs, but not the number of reared juv. of successful pairs. Therefore, we found no real correlation between the proportion of unsuccessful pairs and reared juveniles of successful pairs ( $r = -0.26$ ). On the other hand, there is a close negative correlation between the number of unsuccessful pairs and the number of young in all pairs ( $r = -0.934$ ).

As a special environmental factor, precipitation between January and May was compared with the percentage of unsuccessful pairs in the district of Potsdam. The result obtained was a moderate negative correlation between the two factors ( $R = -0.44$ ). This fact confirms, to a certain degree, the protective effect of the water level for the clutch and the relation between breeding success and the amount of rainfall.

	$\bar{x} \pm s$	s%	From $\bar{x}$ To
% pairs without breeding success	$23.3 \pm 7.4$	31.8	13.5 - 35.3
Juvenile / pairs with breeding success	$1.42 \pm 0.06$	4.2	1.29 - 1.64
Juvenile / all pairs attempting to breed	$1.09 \pm 0.13$	12.0	0.87 - 1.48

Table 1. Reproduction results from 1517 breeding pairs 1977-86.

	Potsdam	Schwerin	Cottbus
No. years included	7	9	3
No. breeding pairs	444	949	124
% pairs without breeding success			
$\bar{x} \pm s$	$18.9 \pm 4.7$	$24.2 \pm 8.5$	$30.5 \pm 9.9$
s%	24.9	35.1	32.5
Juvenile / pairs with breeding success			
$\bar{x} \pm s$	$1.41 \pm 0.12$	$1.42 \pm 0.07$	$1.41 \pm 0.09$
s%	8.5	4.9	6.4

Table 2. Comparison of reproduction results in three different districts 1977-86.

#### PROPORTION OF JUVENILE CRANES

The rearing result of all 1,517 pairs with breeding trials was 1.09 juv. in the GDR. In Scandinavia only 0.61 juv. were recorded for 156 pairs (Bylin 1980; Nilsson 1981; P. O. Swanberg, pers. comm.).

The portion of young at the gathering places of Central Europe amounted to 14-16%. On the other hand,  $12.3 \pm 1.1\%$  juv. were observed among 22,740 Scandinavian cranes at resting places along the southern Baltic Sea.

Comparison of these numbers of the Central European and Scandinavian crane populations shows that a better reproduction rate can be expected in Central Europe. This fact makes intelligible the increasing breeding population in our region, whereas in Scandinavia the population seems stable.

Sterbetz (1987) found  $11.4 \pm 4.1\%$  juv. among 71,497 resting cranes in Hungary. The Finnish cranes, which migrate south over Hungary, included only  $9.0 \pm 4.4\%$  juv. out of 6,137 resting birds in 1983-85 (Karlin and Raivio 1987; Rinne 1987, pers. comm.). This low result corroborates the Finnish suspicion of a decreasing population.

#### SUMMERING NONBREEDING CRANES

Fifty-six summer sites for nonbreeders have been identified in the GDR, where 10 to 250 cranes stay from May to July. Field observations show a ratio between breeding and summering birds of about 1:1. This result is compatible with a computer population model showing 47-49% summering cranes (Alonso et al. 1986b). Within this percentage of summering birds, there are more nonbreeding adults than immatures. With regard to these findings, it is possible that some pairs do not breed annually. Similar behavior was observed by Andronov (pers. comm.) in red-crowned cranes *Grus japonensis* in the Amur Region of U.S.S.R.

The movements of crane groups on the summer sites are more widespread than they are on the resting places in autumn. Between the middle of May and the end of June are seen the smallest number of birds. In several cases, the birds are hidden as they sleep all day. Half of the birds seem to molt at this time. There is little information, however, about their behavior during this period. In July, the summerers gather and develop the usual daily rhythm. Larger summering places now become gathering sites.

The distribution of summering cranes and their sites in the 10 larger districts in the GDR is related to the breeding density ( $r = 0.947$ ). This aspect of their behavior points to the return of most nonbreeders to their native district.

#### GATHERING AND RESTING

The number of cranes increases at most sites in July due to the gathering of nonbreeders and unsuccessful pairs. From the end of July families with young gather more and more, resulting in an increase of juveniles up to the end of September. Cranes possibly gather annually in the same, or at least neighboring, places. In our 10 larger districts, the comparison of the number of gathering and breeding cranes ( $r = 0.930$ ) as well as the number of gathering and summering birds ( $r = 0.917$ ) shows highly positive correlations. This behavior points to a close territorial connection among these three groups of birds.

In the GDR, more than 30 gathering and resting sites are known (Prange 1986, 1987). Many of them consist of several

sleeping locales which are related to biotypes as follows:

- extended sandy shallow water areas behind the Baltic Sea coast (8),
- lagoons in low swamps and old peat bogs (15),
- shallow lake shores (10),
- water areas in fields, meadows and river banks (6),
- residual water ponds and rinsing fields of brown-coal mines (3),
- fish ponds, waste water ponds and a storage reservoir (7).

In the last two decades we lost five smaller gathering and resting places, and four new sites were developed. Losses occur with heavy disturbances due to human activities, and a decrease in the groundwater level after demelioration in the vicinity, or after foundation of new brown-coal mines. Possible change of roosting sites is restricted in an intensively cultivated landscape. Therefore, most of these sites have the status of protected areas in the GDR. Their care demands, in some cases, the cutting of reed, burning of sedge, prevention of tree growth, and regulation of water, as well as limitations on goose hunting and other activities of people.

Most of the gathering places become resting sites during migration. Table 3 includes some parameters for these sites.

The most important resting areas are the island environments of Rügen and the Bock on the Baltic Sea coast. They are used between August and November by a large part of the Scandinavian crane population (see Table 4). In the 1960s and 70s, 10-20,000 birds rested here, but the maximum numbers increased up to 20-30,000 cranes in the 1980s (Prange 1966, 1974, 1987; Prange et al. 1987). This increase in numbers took place in the Bock area in particular. Nearly 10 km<sup>2</sup> of shallow water banks allow the cranes to choose favorable sleeping sites depending on changing conditions (water levels, wind directions, and flying routes to the feeding grounds). Particularly important is the fact that people are not permitted to visit this region. On the other hand, serious disturbances at the main roosting site of Rügen — caused by varying water levels, visitors, goose hunters and agricultural activities — are diminishing the numbers of resting birds. Both places, however, are sites for "long term resting" in the moderate

climatic zone in Central Europe. The birds stay as long as possible before mass departures take place beginning at the end of October.

Inland, the cranes stay at several sites, in resting numbers up to 5,000 (Prange 1987). From the end of September on, there are permanent movements of smaller or larger groups from east to southwest. This is the reason for significant time differences in the resting parameters between eastern and western, as well as northern and southern, places (Prange 1984, 1986, 1987). These differences of 1 to 2 weeks are remarkable, considering the small area of the GDR. Mass departures take place at these sites too, but they are not as impressive as those at the Rügen Bock area.

Finally, along the southwestern migration routes there are "short term resting" places, which are used only during the migration periods. Resting groups, as a rule, stop no longer than one or two nights, depending on weather conditions. The numbers of resting cranes vary greatly from

	— Autumn —		Spring
	1965-72	1977-85	1966-85
No. years included	3-5	9	3-5
Date of first arrival / $\bar{x}$ from - to	beginning of August		8.3 20.2-18.3
Date of last departure / $\bar{x}$ from - to	6.11 28.10-17.11	21.11 9.11-10.12	end of April
Main resting day / $\bar{x}$ Rügen $\bar{x}$ Bock from - to	13.10 20.10 8.10-5.11	15.10 22.10 23.9-17.11	13.4 2.4 30.3-19.4
Resting weeks / $\bar{x} \pm s$	13.3 $\pm$ 3.2	14.8 $\pm$ 1.6	7.2 $\pm$ 1.5
Maximum cranes simultaneously $\bar{x}$	?	15,300	3,900
absolutely	15,000	26,000	6,800
Crane resting days / period week	516,000 38,800	722,000 48,800	88,600 12,300

Table 4. Resting parameters of the Scandinavian cranes at the German Baltic Sea coast (Rügen - Bock area).

Maximum number of cranes	Inland				Coast
	$\leq 100$	100-400	400-1,000	1,000-5,000	$> 5,000$
Distribution of the places / n	9	8	7	5	2
Sum of maximum numbers / n	630	1,720	4,230	14,530	27,000
Date of maximum numbers / $\bar{x}$	16.10	31.10	1.11	4.11	2.11
Proportion of cranes gathering / % <sup>a</sup>	83	43	28	17	1
Proportion of cranes resting / % <sup>a</sup>	17	57	72	83	99

Table 3. Parameters of the gathering and resting places in the GDR - autumn 1985.

<sup>a</sup>Gathering calculates all cranes on sites at the end of September; resting designates the difference between gathering cranes and the maximum numbers in October or November.

week to week and from year to year. The variation coefficients (s) of the annual maximum numbers are higher at those places that lie west of the closed breeding area than in the "long term resting" sites of the Baltic Sea coast.

Of course, there are transitions between the different kinds of resting places. The gathering and resting sites inland, in particular, can be both "long and short term resting" places, whose resting numbers can change due to alterations in local conditions and in migration routes. Table 5 shows three examples of places where the roosting conditions have not changed. The varying frequentations of cranes, however, are the result of changed migrations from east to west. Furthermore, Table 5 points to the fact that s% increases with increasing numbers of resting birds. This is a consequence of annual variation in the course and time of migration.

Daily rhythm and behavior of the birds are similar in all kinds of places, except for the time of their evening arrival at the sleeping sites. This last behavior depends on the location as follows: the smaller and more endangered the roosting site and the less open the view of the vicinity, the later the cranes will arrive. In these cases, they need a neighboring "intermediate landing ground." From there, they go to the roosting places well after dark. In late autumn, however, the frequency and the time of use of these grounds decrease with the length of the day.

#### MIGRATION IN CENTRAL EUROPE

In Central and Western Europe are two important migration routes. The eastern one takes the cranes from Finland, the Baltic Soviet Republics, and eastern Poland south across Hungary and the Balkan countries to Tunisia. The western route leads the birds southwest from Scandinavia, Poland, and the two German states to Spain. A border line area between the flyways is formed by the Wiszla river in eastern Poland, but its annual shifting is completely unknown.

The western route has two divisions. The first begins in Scandinavia and the second in Poland. The divisions merge in our region, making the entire migration area as wide as the breeding area (up to 340 km from north to south) of Central Europe.

The northern cranes arrive at the German Baltic Sea coast between the middle of August and middle of October. The eastern cranes reach the inland from the end of September on. The maximum numbers in the northern migration come at the end of September; in the eastern, at the end of October (Mewes 1976). Furthermore, the northern portion of the migration route has two subdivisions in Sweden as well. The apparently more important one runs along western Sweden and crosses the Baltic Sea, heading south with a width of 70-90 km. Its destination is the Rügen-Bock region. The other route runs along the eastern coast of Sweden. It is channeled by the resting place on the island of Oland, Sweden and goes from there to the Polish coast. In Poland, these cranes spread over the northwest part of the country to reach our territory, with the migration occurring from east to west in autumn. There are two main flyways: the first runs near the Baltic Sea coast and ends for most of the flocks at the Bock area; the second follows the glacial valley Thorun-Eberswalde, north of Berlin, and ends at three large resting places in the district of Potsdam.

The larger numbers of cranes in the 1980s is due to the extension of the resting period and to a more intensive migration westward. The first alteration is caused by a milder climate and new traditions, the latter (we think) by an eastern transition of the dividing line between the two main migration routes. But it is necessary to gather more information and to band more diligently young cranes in their eastern breeding grounds.

Members of the GDR crane protection group counted 38,000 cranes simultaneously at about 90% of all gathering and resting places on 2 and 3 November 1985. Crane distribution was 63% along the coast and 37% inland. Before this time of maximum resting numbers, 17% of all of the flocks had already passed the Rhein river (B. Behlau, pers. comm.), and after this time, further groups arrived from the east. It is clear, therefore, that at least 46,000 cranes used the western route in 1985 (Prange 1987). This estimate by our working group for crane preservation correlates well with a count of 40-50,00 birds in Spain (Alonso et al. 1986a).

In 1986, the resting situation produced similar results. About 41,000 birds were in our region 25-26 October. After an enormous mass departure 2 November of nearly 24,000

Crane Places	Period	Main Resting Day	Maximum Numbers				Percentage of All Cranes	
			$\bar{x}$	$\pm$	s	s %	Gathering	Resting
Northern area (Muritz lake)	1947-59	13.10	4050	$\pm$	3620	89	10	90
	1960-68	2.10	322	$\pm$	122	38	90	10
	1971-81	1.10	318	$\pm$	83	26	95	5
	1982-86	24.10	813	$\pm$	425	52	40	60
Middle area (Havel river)	1968-76	22.10	456	$\pm$	185	41	55	45
	1980-86	2.11	2960	$\pm$	1964	66	10	90
Southern area (Luckau county)	1960-68	11.10	204	$\pm$	53	26	70	30
	1969-76	15.10	220	$\pm$	26	12	80	20
	1977-86	25.10	460	$\pm$	394	86	30	70

Table 5. Alterations of resting intensities within longer periods at three inland places with constant roosting sites.

cranes, the following week an additional 4-5,000 arrived from the east, filling the inland resting places in particular. About 45,000 cranes rested in GDR in 1986. Assuming an unknown proportion of only 10% for birds which flew over or departed before the maximum value was reached, we calculate that not fewer than 50,000 birds migrated in 1986 via the European western route. The resting distribution was in 1986 as in 1985, with 62% along the coast and 38% at inland places.

Central Europe can be considered as a large "long period resting" area with current movements toward the southwest. Many "short term resting" birds can be seen at single places situated along this migration route, forming a piece by piece pattern of autumn movements. Mass departures are more impressive. These flights overcome in a short time much of the distance between the "long period resting" area in the moderate geographic zone and the wintering places in the Mediterranean Sea region. As a rule, the farther the birds from the terminus, the more frequently flights are interrupted. Unfavorable weather conditions, such as heavy fog or storms, can suddenly stop the migrants. Furthermore, observers have noted changes to the north or south from the normally-used main western migration route, due to strong weather influences such as heavy counter winds or high warm air currents that drift sideways (Deppe 1978). For example, more than 10,000 cranes drifted about 150 km to the south in both German states, and to the east in France, on 2 November 1986.

While in autumn the resting birds stay as long as possible in Central Europe, they hurry in spring to reach their breeding places, in our region arriving during the first two weeks of March. But in northern Europe they arrive up until the end of May. In autumn, the southernmost resting cranes stay at their places longer than other cranes. Thus the southern population will be overtaken by the northern migrants, a behavior pattern well-illustrated by the white stork *Ciconia ciconia* (Schüz 1971).

In spring, northern birds, especially nonbreeders, remain at the Baltic Sea coast resting places for only a few days or weeks due to their weaker migration drive. Nevertheless, the resting period is shorter and the number of birds is lower than in autumn. Different timing of the spring migration of the more southern and northern populations as well as of the breeders and nonbreeders normally results in two migration waves in the German countries (Prange and Wei 1987). Migrating homeward, the northern population does not take a roundabout way across Poland. They migrate directly to the north, a digression off their main route of about 50-60 km. The spring migration from west to east inland of the GDR is not intensive and concerns only the German and Polish breeding population, including its nonbreeders of course. Winter weather conditions can interrupt the home flight, leaving cranes sometimes to spend the night on the ice of well-known roosting places.

#### WINTERING IN CENTRAL EUROPE

During the last decade, resting cranes have stayed on average two weeks longer in autumn in Central Europe than they stayed decades ago. Mild climate conditions and

new traditions since 1974-75 account for this change. Furthermore, an increasing number of cranes are trying to pass the winter in our region. In 13 years, birds wintered 8 times ( $\bar{x}$  = 164 cranes/winter, maximum number, 1982/83 with 1,164 birds). The negative correlation between wintering cranes and the sum of daily mean degrees below zero ("sum of cold") from December to February was only moderate ( $r$  = -0.51). This points to the fact that other conditions (snow cover, food availability) influence wintering to a similar degree.

A comparison of winter residences in Hungary, France, and the GDR (see Salvi 1984; Mewes and Salvi 1989; Sterbetz and Prange 1989) resulted in high correlations among these three countries between 1976 and 1982/83 ( $r$  = 0.88-0.98). This suggests that large-area weather conditions influence wintering along migration routes. The numbers in Table 6 point to the increase in wintering from north to south and from east to west. These relations are similar to the time-of-departure relations in different geographical regions. Thus, in France the cranes stayed in every winter, and the highest number of birds was also recorded. In 1982/83 the maximum number of wintering birds was established, with the 4,544 cranes in France and the GDR accounting for nearly 10% of the whole population migrating westward. The wintering birds normally stay for weeks and months at traditional crane places. But they can be very mobile, too. During unfavorable weather, they usually move. They stop as soon as possible, because there is no real migration drive in midwinter. Many of them have returned already in February, when snow melts and temperatures rise (Mewes and Salvi 1989).

	GDR	Hungary	France
Years / total	7	7	7
Years / winterings	4	6	7
Wintering cranes / total	1,857	3,116	4,650
Wintering cranes / $\bar{x}$ years	265	445	665
Wintering cranes / $\pm$ s	426	936	1,123
Wintering cranes 1982/83	1,164	2,250	3,380

Table 6. Winter residences in the GDR, Hungary, and France, 1976/77 - 1982/83.

#### CLOSING COMMENTS

At present, there is some concern over the increase of resting cranes inland and at the Baltic Sea coast, in particular. Resting flocks of 25,000 cranes at the Bock area, however, do not noticeably interfere with intensive grain production. Financial loss in this crop region is less than 1% in fields averaging 100 to 150 ha. This loss will be partially compensated for by the district's government, which

cultivates annually up to 100 km<sup>2</sup> of grain fields. A few ha of wheat and maize, however, are totally destroyed.

The common crane is completely protected as an endangered species in both German countries. This protec-

tion extends to the breeding places and roosting sites. Many honorary nature conservers are involved in the work of this program. Crane areas are observed locally by ornithologists who cooperate with the central crane protection group.

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## COSTS AND BENEFITS OF FLOCKING IN WINTERING COMMON CRANES

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### ABSTRACT

Using the feeding rate as an indicator of individual fitness, we analyze the costs and benefits of flocking in wintering common cranes *Grus grus*. Cranes tend to form larger and denser flocks where food density is high. Large flocks, encouraged to form mainly by local enhancement at sites, enable individual birds to spend less time scanning for predators and more time feeding. Large and dense flocks, however, may cause an increase in aggressive interactions which decrease the food intake rate. Our preliminary data support the dynamic equilibrium flock size concept, rather than the stable optimal flock size from classical Optimal Foraging Theory.

### INTRODUCTION

Flocking in birds has usually been explained in terms of costs and benefits to individuals. The approach to sociality has evolved from Crook's classic work (Crook 1964, 1965, 1970) to recent interpretations based on game theory (e.g., Pulliam and Caraco 1984). Spatial and temporal distribution of food resources (Brown and Orians 1970; Crook 1970; Wiens 1976) and predation (Pulliam 1973; Alexander 1974; Bertram 1978; Rubenstein 1978) are well recognized environmental parameters that can be related to flock size. Wintering common cranes are gregarious and spend most of their time feeding, thus providing a good opportunity to study environmental correlates of flocking.

In this paper, we present some results of a study of the costs and benefits of common crane winter flocking, using the feeding rate as an indicator of individual fitness. Although such an analogy is a simplification of the actual situation, feeding rate has been widely used in field studies on flocking behavior in birds (Krebs and Davies 1984; Barnard and Thompson 1985).

The results presented are based on only about one third of the field data gathered and are thus preliminary.

### STUDY AREA

The study area, Gallocanta in northeast Spain, is a basin of 53637 ha, most of which is intensively cultivated farmland: mainly wheat *Triticum aestivum* and barley *Hordeum vulgare*, but also with sunflower *Helianthus annuum* over 10-15% of the surface. Cranes feed on the waste seeds left after harvest on the soil surface in cereal and

sunflower stubble fields, and also dig up the grain from sown cereal fields.

### METHODS

During the winter seasons 1984-85 and 1985-86, we recorded the following parameters related to flocking and feeding behavior of wintering cranes: *flock size*, *mean interindividual distance* in bird lengths, *time of day*, *vigilance effort*, both as the percentage of birds and percentage of time in alert attitude, *age* of the birds (juvenile or adults), *food availability* where each flock was feeding, *feeding rate* in successful pecks per minute (as indicated by the swallowing movements of the bird's head), and *aggression rate* in numbers of aggressive interactions per three minutes and per number of birds considered.

Food availability was measured in 20 randomly selected samples (25 × 25 cm) in each field where a flock had previously been observed. The mean dry weight of food for each field was then calculated. To obtain a mean feeding rate for each flock, 10 samples of one-minute observation were tape-recorded detailing the pecks, paces, and any other activity of the birds. A telescope (80-130x) was used for all the observations.

### RESULTS AND DISCUSSION

#### Costs and Benefits of Flocking

Among the main selective forces favoring flocking in birds during the non-reproductive season, *predation pressure* and *feeding optimization* are probably the most important.

The main anti-predator benefits are 1) dilution of risks to the individual in the flock, 2) predator deterrence and mobbing, and 3) less time spent scanning by the individual and thus more time to feed. The only important predation-related cost is that flocks are easier for predators to locate.

As for the feeding-related factors, the main benefits for the cranes are 1) information mechanisms that enable an easier location of food patches, 2) reduced risk of starvation, and 3) avoidance of foraging in already depleted areas. The main food-related costs are the increase in aggressive interactions and intra-species disturbances, and the rapid depletion of food.

#### Time Budgeting

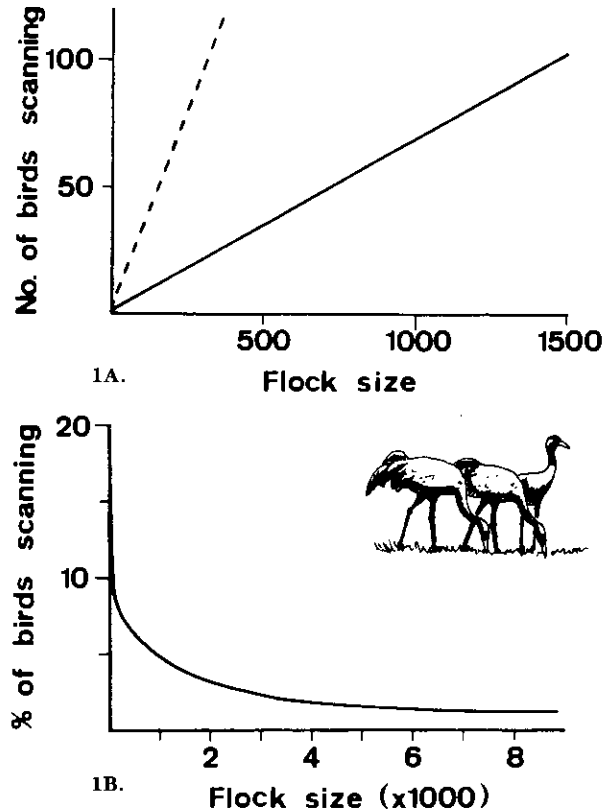
Adult wintering cranes devoted 77% and juveniles 83% of their total daylight time to feeding plus scanning. Flock size and the time spent scanning by an individual are inversely related (Figure 1). Although the total number of birds scanning in a flock increases with its size, the percentage of birds scanning decreases; thus, with increasing flock size there is an increased savings of vigilance time (difference between slopes in Figure 1A). Thus, a reduction in time spent scanning enables the time devoted to feeding to increase.

Another way of considering the anti-predator scanning is represented in Figure 2, which indicates the decrease in flock and individual vulnerabilities with increasing flock size. There is a flock size threshold over which more birds do not add any scanning advantage, as already some individuals are always alert. Vulnerability of these large flocks is thus virtually eliminated. Individual risk decreases even faster as flock size increases, as a consequence of dilution. Once again, very large flocks have no significant increase over intermediate sized flocks in anti-predator advantage.

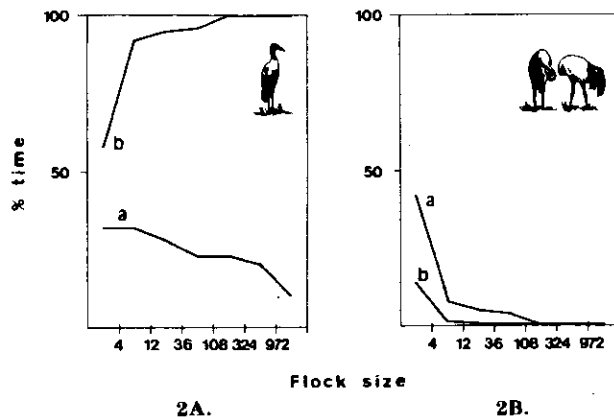
Pulliam (1973) and Pulliam et al. (1982) developed a model to predict the probability of detecting a predator by flocks of different sizes. The expected scanning rate in a flock of 200 cranes would be, following Pulliam's model, 0.2 scans per minute in order to detect a predator that would take ten seconds to approach the flock. The scanning rate measured in the field for groups of around 200 birds is 1.07 scans per minute. This high rate suggests that being alert not only serves to detect predators but also fulfills a second important function: obtaining information, probably related to feeding, from other members of the flock.

#### Flocking and Feeding Enhancement

There are numerous studies showing that flocking is advantageous when food is difficult to locate (e.g., Hinde 1952; Morse 1970; Cody 1971; Wiens 1976). Particularly when food is patchily distributed and unpredictable, gregarious species may find food patches more easily than isolated birds can (Crook 1965; Newton 1967; Horn 1968; Lack 1968; Wiens 1976). Some evidence of this advantage has also been recorded in wintering cranes (Alonso et al. 1984; Alonso et al. 1987). In cranes, as well as in many other species (Krebs 1974; Barnard and Thompson 1985), it has



**Figure 1.** Relation between number (A) and percentage (B) of birds scanning and flock size. A: solid line:  $r=0.77$ ,  $n=96$  flocks,  $p<0.001$ . The dashed line represents the expected increase in number of birds that should be scanning, assuming that the time spent scanning by each individual is independent of flock size and equal to the time spent scanning by members of flocks of 2-10 cranes. B:  $r=-0.39$ ,  $n=96$  flocks,  $p<0.001$ .



**Figure 2.** Decrease in flock and individual vulnerabilities with increasing flock size. A: (a) mean time spent scanning by an individual for each flock size-class considered; (b) % time in which at least one of the members of the flock is scanning. B: (a) vulnerability of the flock (=100 - curve(b) of Figure 2A); (b) individual vulnerability (= (a) divided by the mean flock size).

been observed that the presence of birds in feeding attitude induces other birds to join the flock. The size of the flock already feeding could be used as an indicator of the patch quality by other birds.

Our field data show a significant correlation between food density in the patch and feeding rate (Figure 3). Nevertheless, there is apparently a maximal feeding rate for seed densities over around 500 seeds/m<sup>2</sup>. Cranes also tend to form larger and more compact flocks where food density is higher (Figure 4). These relations suggest that cranes already feeding in rich areas, at high ingestion rates, could tolerate lower interindividual distances. Perhaps these low interindividual distances, together with the high percentage of birds in feeding posture in the flock, could also reflect the quality of the feeding patch.

Figure 5 shows the daily variation in flock size and feeding rate. There are two main feeding periods, one in the morning and one in the afternoon, with a mid-day phase of lower feeding intensity. Interestingly, flock size increases through the mid-day, even as feeding rate decreases, presumably as a consequence of satiation. Higher mean flock sizes at mid-day, coinciding with lowest feeding rates, correspond to crane concentrations at resting and drinking places. The subsequent dispersion of the birds in the afternoon coincides with the second feeding period, before cranes gather in late pre-roost aggregations.

#### Flocking and Aggression

Aggression increases logarithmically with size and density of the flock (Figure 6). This relationship has also been demonstrated for other species (e.g., Zwarts 1980; Goss-Custard 1980; Goss-Custard et al. 1984; see other references in Barnard and Thompson 1985). Aggressive encounters probably result in a reduced food intake as a consequence of time wasted for the birds involved, as well as a distraction for the surrounding individuals.

#### Optimal Flock Size

Once some of the benefits and costs of flocking have been analyzed, we can study the variation in the feeding rate with flock size (Figure 7). For adult cranes, the optimal flock size - defined as that size maximizing the feeding rate - is intermediate; but for juveniles, family and small groups are the most advantageous. This difference probably occurs because the juveniles need the quietness of small groups to compensate for their inexperience in finding food. But their parents must take care of them and lose time they could otherwise spend feeding. Families are therefore disadvantageous for parent birds. Small groups are also disadvantageous for adults without young, because the birds have to spend more time scanning. The modal flock size observed in the field, however, is slightly higher than the size optimal for feeding. The high frequency of occurrence of large flocks suggests the existence of other benefits. Overall, the mean feeding rate for adults ( $\bar{x} = 15.3$  pecks/min) is significantly higher than that for juveniles ( $\bar{x} = 12.6$  pecks/min,  $t = 4.58$ ,  $p < 0.001$ ).

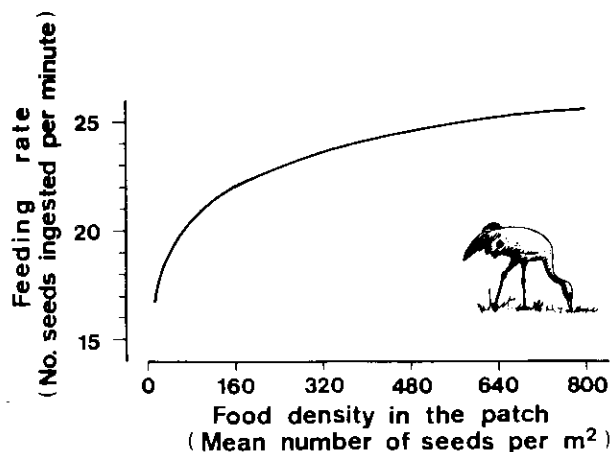


Figure 3. Relation between feeding rate and food density in different patches ( $r = 0.48$ ,  $n = 50$  flocks,  $p < 0.001$ ).

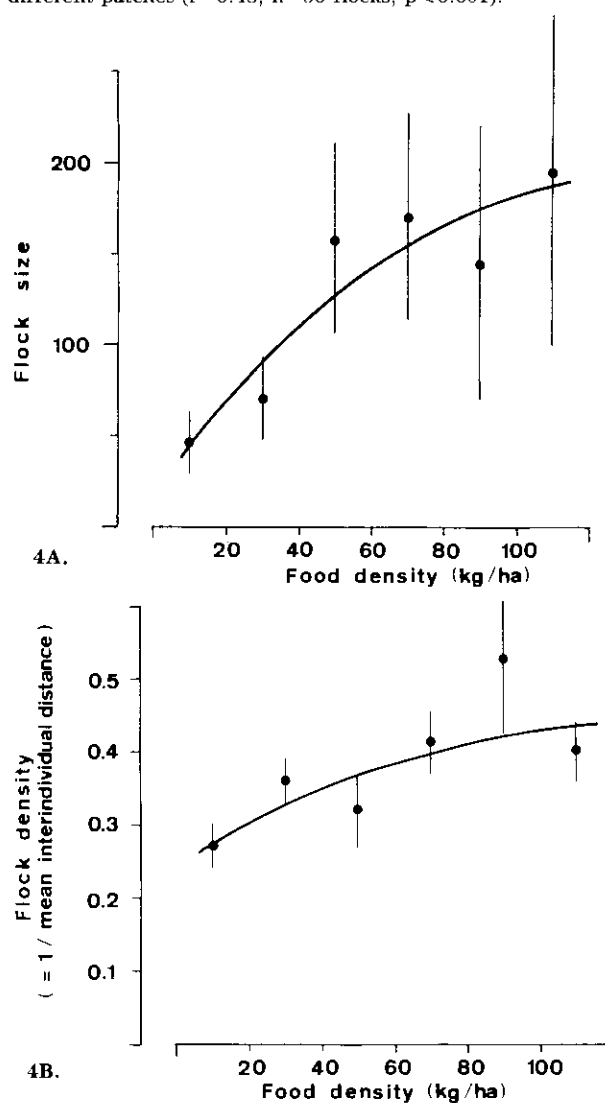


Figure 4. Relation of flock size (A) and flock density (B) to food density. Vertical lines represent 95% confidence intervals.

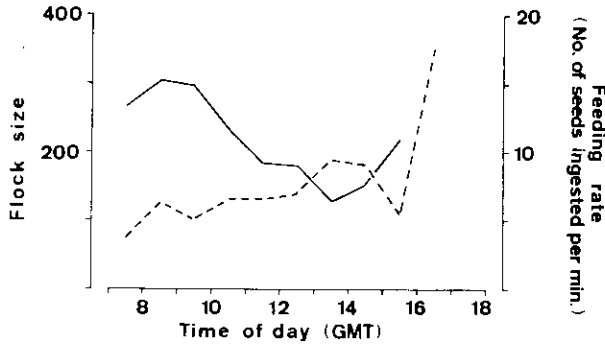


Figure 5. Daily variation in flock size (dashed line) and feeding rate (solid line).

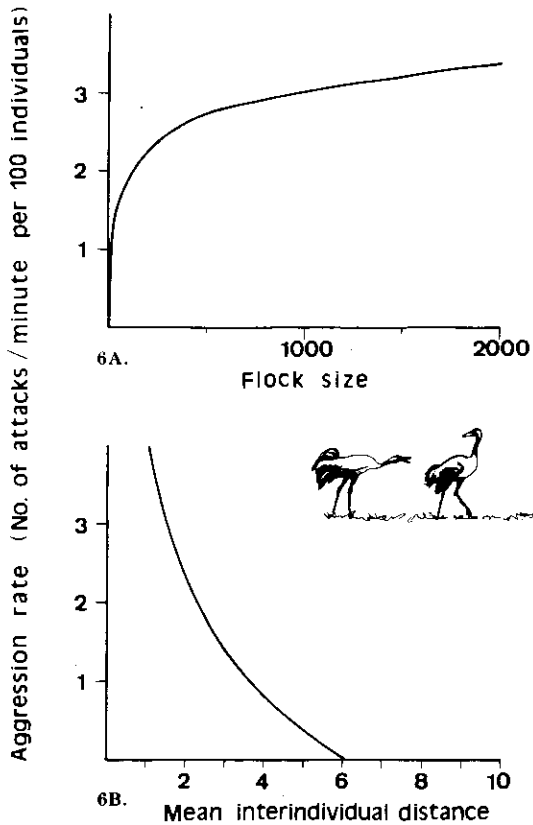


Figure 6. A: relation between aggression rate and flock size ( $r=0.40$ ,  $n=116$  flocks,  $p<0.001$ ). B: relation between aggression and mean interindividual distance ( $r=0.32$ ,  $n=116$  flocks,  $p<0.001$ ).

For each age-class, feeding rates are higher in stubble fields than in sown grounds ( $t = 9.91$  for adults and  $t = 7.23$  for juveniles,  $p < 0.001$  in both age-classes). This difference is due to the seeds being easier to find in stubbles, where they remain as waste grain on the surface, than in sown fields, where they have to be dug up. The total amount of food obtained per unit time, however, is approximately the same in both ground types, as the higher weight of the sown grain compensates for the difficulty of digging it up.

It should be pointed out that the concept of optimal flock size used in this paper corresponds to the classical Optimal Foraging Theory (see Krebs and Davies 1984), where the optimum is considered as a maximization of feeding efficiency, balancing simple costs and benefits. Nevertheless, as suggested by Davies (1982), a dynamic concept of optimal flock size is more realistic (see also Krebs and McCleery 1984; Pulliam and Caraco 1984). Flock size may be influenced by changeable conditions including: 1) environmental factors (temperature, food availability, predation risk, etc.), 2) individual condition (sex, age, physiological state, etc.), or 3) the behavior of other individuals. These conditions determine continuous displacements of the optimum, preventing individual fitness from being the maximal possible. But, the different strategies adopted by the individuals in the population constitute a set of evolutionary stable strategies (King's College Sociobiology Group 1982; Krebs and Davies 1984).

Our preliminary results agree also in principle with the predictions of Fretwell's (1972) "Ideal Free Distribution" model. This model proposes that with increasing population size, individuals would first select the habitat offering the highest quality when two habitats of different quality are available. The reduced fitness of a bird, however, in the poor habitat would be compensated for by lowered competition there, so that an equilibrium between habitat quality and population density would be obtained. In fact, with our data, the result of dividing the quality of each habitat—kg food per surface unit immediately surrounding each individual crane as measured through its interindividual distance—by the mean flock size in that habitat is approximately a constant. Cranes therefore obtain equivalent amounts of food in stubble and sown fields, respectively 0.49 and 0.40 g per minute.

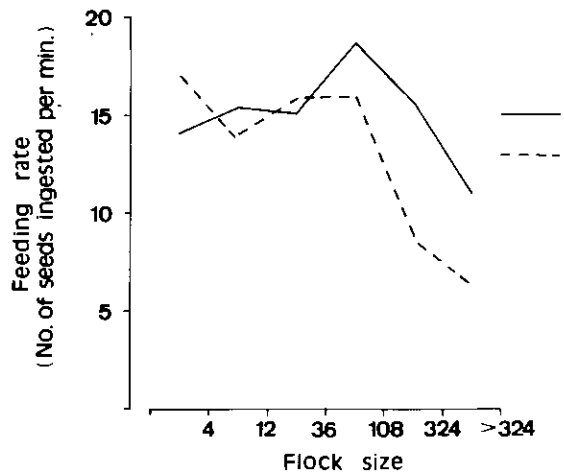


Figure 7. Variation in feeding rate with flock size in adults (solid line) and juveniles (dashed line). Horizontal lines represent mean feeding rates respectively for adults (solid line,  $\bar{x} = 15.31$  pecks/min,  $n=93$  flocks) and juveniles (dashed line  $\bar{x} = 12.60$  pecks/min,  $n=74$  flocks).

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## SIMULATIONS ON A COMMON CRANE POPULATION MODEL

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### ABSTRACT

A simple deterministic model describing the population dynamics of Western European common cranes *Grus grus* has been developed. Here we present an updated version of the model and test the effects of various natural and man induced events. Low hunting rates (5% of total population or 1,000 birds annually) do not significantly reduce the size of the population, due to the density-dependence of survival assumed in the model. High decreases in annual productivity (50%), small decreases in survival (10%), and certain catastrophic events result in the extinction of the population.

### INTRODUCTION

Simulation modeling has been increasingly applied during recent years to wildlife ecology and management (Miller and Botkin 1974, Miller 1978, Johnson 1982, Verner et al. 1986). This technique is especially useful for understanding population dynamics of long lived species, given the difficulty in obtaining long series of demographic data, as well as in detecting and analyzing the effects of natural or man-induced events that affect these populations. Most of the living crane species seem to be declining, and some of them are endangered. Despite present conservation efforts, it will hardly be possible to plan future management actions without a previous understanding of the dynamics of crane populations. The common crane is particularly suitable for such investigations, as its present status enables the gathering of relatively extensive demographic information.

In this paper we present a second version of a simple population model (Alonso et al. 1986a) similar to those produced for the sandhill crane *Grus canadensis* (Miller et al.

1972, Johnson 1979), and simulate the responses of the population to various events affecting the survival and reproduction of cranes.

### DEMOGRAPHIC PARAMETERS

Two of the parameters used in the model — population size and percentage of juveniles — were obtained during the last eight years (1979-1986) at the wintering areas of the species in Spain. The size of the Western European population has been estimated at around 40,000-50,000 birds (Alonso et al. 1986b and unpublished data; Prange 1984 and pers. comm.).

The percentage of juveniles was recorded each autumn, with the unweighted average for the eight years being 13.5% (Table 1). The adult:juvenile ratio was obtained at random, by counting unselectively all flocks as they were found in the field. This age-ratio is only valid and representative of the whole population if a large number of birds can be assigned an age each season in the same area and

time, and under approximately equal conditions. For a more detailed sample selection procedure see Alonso and Alonso (1987).

Other demographic data — age of first breeding, longevity, and mortality — are still not well understood, due mainly to few individually marked birds. Therefore the data available for the sandhill crane and whooping crane *G. americana* have been used for the common crane in our model. On the basis of recent literature reviews (Walkinshaw 1973; Johnsgard 1983) and captive crane flocks (Archibald pers. comm.) the age at first breeding is assumed to be four years.

Although cranes can live more than 40 years in captivity, most authors estimate maximum longevity of 20-25 years for natural populations (Walkinshaw 1973; Binkley and Miller 1980; Johnsgard 1983). We have assumed the existence of 24 age-classes for the common crane.

The constant adult mortality rates assumed in classic bird population studies (Deevey 1947; Lack 1966) are not in accordance with current longevity data from recoveries of banded birds. This is probably due to the existence of an age-dependent mortality effect (Miller et al. 1972; Botkin

and Miller 1974). In this model we use the age-specific survivorship values estimated for the whooping crane (Binkley and Miller 1980), which are based on annual censuses and age-compositions of that population recorded since 1938. A density-dependent effect on mortality that affects birds of every age and reproductive condition has also been included.

THE MODEL

The model we have developed is a very simple one, based on a sandhill crane model by Johnson (1979) but incorporating the age-dependent effect on survival rate. The program was written in Basic Apple Soft and has been operated successfully on an Apple II computer. Figure 1 shows the complete flowchart of the model, including (a) the assumed 24 age classes, (b) the distinction between the first three nonreproductive age classes and the other classes of sexually mature cranes, and (c) the type of curves (= reverse logistic functions) that govern the density-dependent effects on recruitment and survival rates.

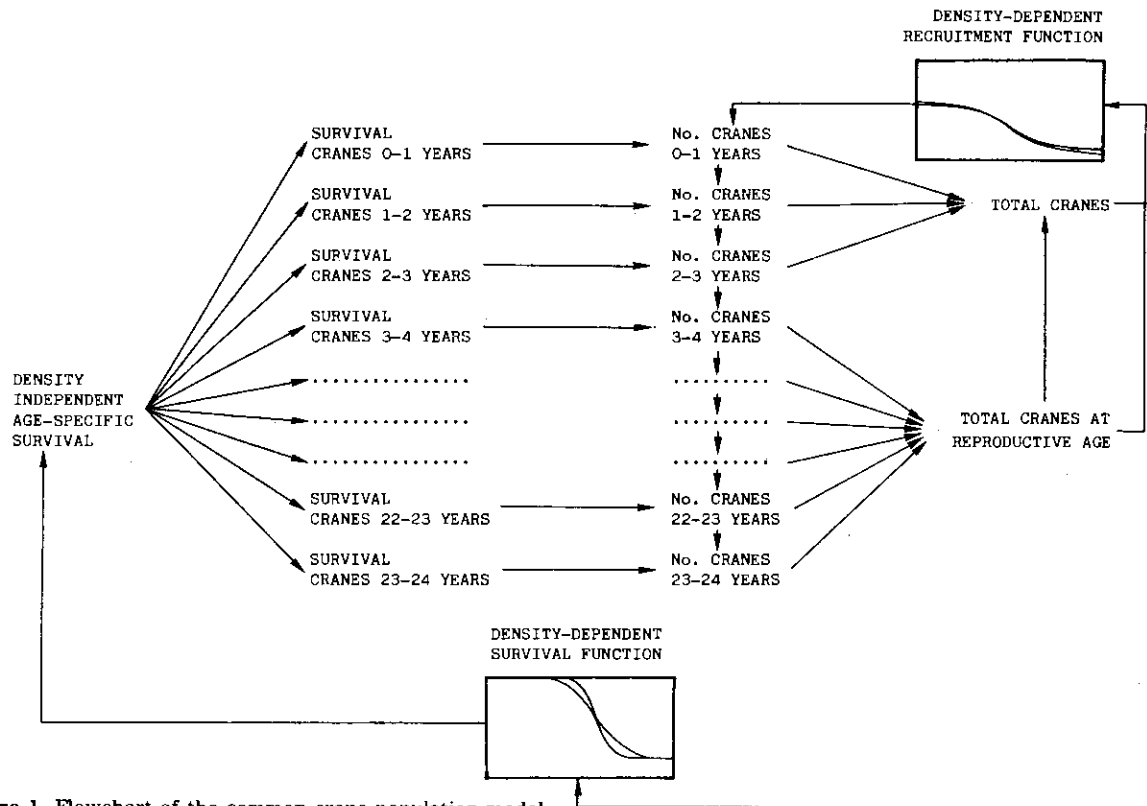


Figure 1. Flowchart of the common crane population model.

Year	1979	1980	1981	1982	1983	1984	1985	1986	Total
% Juveniles	12.48	12.95	14.17	12.12	11.67	12.34	19.02	13.27	13.50
Number of Cranes Aged	5,890	6,508	20,301	17,991	20,917	12,898	21,468	15,853	121,826

Table 1. Age composition of the western common crane population.



The crane population of level I (0-1 years old) is determined by the following equation:

$$\text{BIRTHS} = \text{BC} \times \text{P}$$

where BC = number of sexually mature cranes; and P = productivity, or annual recruitment rate.

In this way, reproduction is simplified in the present model to a single process that depends only on the breeding population and productivity expressed as recruitment of young birds to the winter population. The model ignores hatching and fledging success, for which no data are available. The subsequent age classes or levels are calculated as follows:

$$\text{For } I = 2 \text{ to } 24, C(I) = C(I-1) \times S(I-1)$$

where I = age class, or level; C(I) = number of cranes of age I; and S(I) = survival rate of cranes at age I.

These density-independent survival rates are assumed to be different for each age-class considered, due to the above mentioned age-dependent mortality effect. Each age-specific value is also affected by a reverse logistic function that accounts for the effect of population density. The survival rate declines at high population levels:

$$S(I) = \frac{S_m/S_M \times [1 - M(I)] + \frac{[1 - M(I)] \times (1 - S_m/S_M)}{1 + e^{[A \times (T - S_I) / 1000]}}}{1 + e^{[A \times (T - S_I) / 1000]}}$$

where S(I) = survival rate of cranes at age I;  $S_m/S_M$  = ratio between minimal and maximal assumed survival rates, i.e., lower and upper asymptotes of the logistic function; M(I) = density-independent mortality at age I, or natural rate of deaths due to accidents, predation, etc.; A = parameter that regulates the rate of decline of the logistic curve; T = total number of cranes in the population; and  $S_I$  = number of cranes at the inflection point of the curve.

Recruitment rates are also assumed to be density-dependent, varying from high values at low population densities to low values as the population grows:

$$P = \frac{R_M}{1 + e^{[B \times (T - R_I) / 1,000]}}$$

where p = recruitment rate of the population;  $R_M$  = maximal theoretical recruitment rate (see below); B = parameter that regulates the rate of decline;  $R_I$  = number of cranes at the inflection point of the curve and T as in the preceding equation.

This recruitment rate applies only to sexually mature birds, cranes at least four years old.

Each simulation starts with an initial population of 20,000 cranes. This initial population is assumed to have an age distribution identical to that calculated for the whooping crane by Binkley and Miller (1983). The model is then run for 50 years.

The initial values of the parameters A and B were estimated from the figures and equations given by Johnson (1979). Later, combinations of both parameters between 0.01 and 0.5 were tested. As these parameters govern the form of the logistic curve, it is virtually impossible to determine their values exactly with the data available at present.

$S_m/S_M$  regulates the effect of population density on survival: high values of this parameter indicate low density-dependence of survivorship. We tested values of 0.5 to 0.9.

For  $S_I$  and  $R_I$ , various values around the real size of the crane population have been considered (35,000-60,000), with the assumption that the population is stable. The values for  $R_M$  were estimated in four different ways. (a) If we assume that each mature bird pairs in spring and each pair produces two chicks that survive until their first winter, then out of 100 cranes, 63.7 birds will be  $\geq 4$  years old (following Binkley and Miller 1983) and produce a maximum of 63.7 young, which will represent 39.1% of the next winter's population. (b) If instead of two young per reproductive pair we consider our field average of 1.35 young per pair (our own unpublished data), the maximum possible percentage of juveniles will be 30.1%, also assuming that all mature birds breed. (c) One may also assume that the annual recruitment observed for the whooping crane represents a maximal value, because the small population of this endangered species (18 birds in 1938, increasing to more than 100 at present) should stay at the left extreme of the density-dependent inverse logistic function of recruitment. The average for this species during the 43 years 1938-80 is 14.5% juveniles in the winter population. (d) We could also use the maximal percentage of juveniles observed for the whooping crane, which was 31.8% in 1939. We think, however, that possibility (d) may be influenced by the stochastic nature of the breeding process and should therefore be considered as an exceptionally high value, not representative for  $R_M$  in our deterministic model. Possibility (a) is also hardly representative, as it does not account for natural, density-independent losses of eggs and young up to the first winter when the simulation starts. Thus, we have tested as the most realistic values for  $R_M$  those values between 0.10 and 0.30.

## RESULTS

We have tried a total of over 400 combinations of the parameters of the survival and recruitment functions, and have selected those (Table 2) that yield (a) stabilized populations between 40,000 and 50,000 cranes, and (b) percentages of juveniles of  $13.50 \pm 1.98$  (= mean of the eight annual values measured in the field  $\pm$  95% confidence interval).

The mathematical simplicity of the model is mainly a consequence of the few data available on the demography of the crane population and its deterministic nature is imposed by the scarcity of information on causal intercorrelations between environmental and population variables (see also Miller et al. 1972; Johnson 1979). The 12 combinations given in Table 2 represent only a selected sample of the series of plausible combinations that are consistent with the above mentioned conditions (a) and (b). Any of the 12 selected combinations of parameters (Table 2) can be used to simulate the behavior of the population in response to different environmental conditions or management situations. We have selected combination no. 12, which yields a total population and a percentage of juveniles closest to those observed in the field.

The main simulated scenarios (Figure 2) include the effects of hunting, variations in productivity, survival, and

age of first breeding, and a catastrophic decrease in the population size. All the experimental situations start after the twentieth year of the model unless otherwise stated.

#### 1. Hunting Loss of 5% Cranes Annually (Figure 2A)<sup>1</sup>

The 5% is assumed to be uniformly distributed among all age classes considered. The consequence will be a decrease in both the total number of cranes and percentage of juveniles by 2.4% and 3.1%, respectively, but both values will stabilize again in less than 10 years. These decreases are less than the 5% annual hunting harvest, due to the density dependent self-regulating capacity of the population.

#### 2. Hunting Loss of 1,000 Cranes Annually (Figure 2B)<sup>1</sup>

The 1,000 cranes are again uniformly harvested from all age classes. The effect is almost negligible: 0.4% decrease in the total number of birds and 1.6% in percentage of juveniles.

#### 3. Productivity Reduced to 80% (Figure 2C)

A yearly reduction in the productivity due, for example, to human interferences in the breeding cycle (loss of breeding habitat through drainage or agricultural transformations, disturbances at nests, etc.) will cause an initial reduction followed by a slight recovery and stabilization at levels around 13% (for population size) and 11% (for percentage of juveniles) lower than those of the undisturbed population.

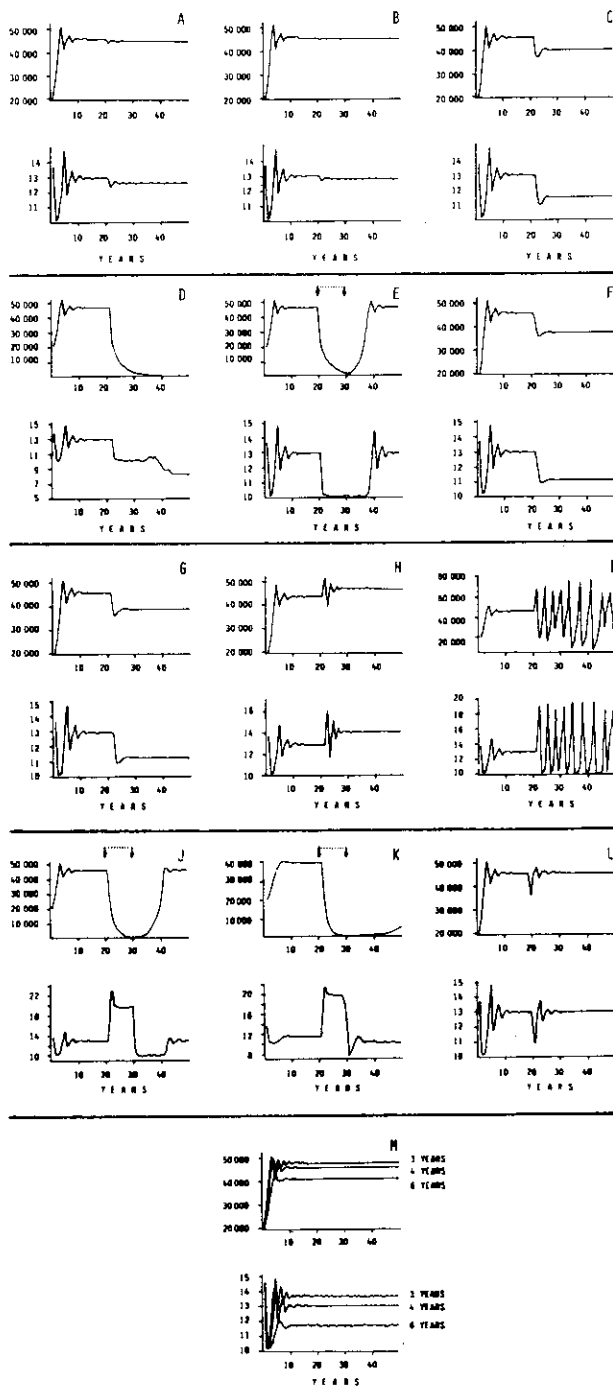
#### 4. Productivity Reduced to 50% (Figure 2D)

The population could not stand such a yearly reduction and would therefore become virtually extinct (less than 150 birds) in about 20 years.

Trial No.	$S_m S_M$	A	$S_I$	$R_M$	B	$E_I$	Total Cranes	% Juv.
1	0.7	0.15	60,000	0.2	0.15	50,000	41,830	11.5
2	0.7	0.15	60,000	0.2	0.15	60,000	45,100	12.9
3	0.7	0.2	50,000	0.2	0.15	60,000	40,400	13.5
4	0.7	0.2	50,000	0.2	0.3	50,000	40,380	13.4
5	0.8	0.15	50,000	0.2	0.15	60,000	40,440	13.5
6	0.8	0.15	50,000	0.2	0.2	60,000	41,080	13.7
7	0.8	0.15	50,000	0.2	0.3	50,000	40,380	13.4
8	0.8	0.15	50,000	0.2	0.3	60,000	41,450	13.9
9	0.8	0.15	60,000	0.2	0.15	60,000	47,100	12.5
10	0.8	0.15	60,000	0.2	0.3	60,000	49,800	13.4
11	0.9	0.15	50,000	0.2	0.15	50,000	40,900	11.8
12	0.9	0.15	50,000	0.2	0.15	60,000	45,290	12.9

**Table 2.** Values of the model variables that yield stabilized population sizes and age ratios similar to those observed in the field.

<sup>1</sup>Note: Simulations 1,2,6 and 7 do not consider negative influence of hunting on behavior, preferred areas, roosting routines, etc. Inclusion of these simulations does not imply endorsement of hunting of common cranes. The authors believe that hunting of cranes in Europe must remain strictly forbidden, and always subordinate to other cultural, scientific and aesthetic interests.



**Figure 2.** Experimental simulations on the model; trial no. 12 (from Table 2) has been used in all simulations. Each simulation represents a period of 50 years. Perturbations of the original model, representing various environmental disturbances, act from year 21 on, except in E, J, and K, in which the disturbance is maintained only between years 20 and 30 (arrows and dotted lines on top of graphs). Each pair of graphs is the result of one simulated scenario: the upper graph of each pair represents the population size, and the lower, the percentage of juveniles. Simulation M shows together the results for the three ages of first breeding considered.

#### 5. Productivity Reduced to 50% for 10 Years (Figure 2E)

In the case of a 50% decrease in productivity in effect only for 10 years, the population would theoretically recover, according to the model. We think, however, that it might be impossible for a natural crane population to recover after decreasing to such a low number of individuals.

#### 6. Hunting Loss of 5% Cranes Annually Plus Reducing the Productivity to 80% (Figure 2F)<sup>1</sup>

This simulation combines the effect of simulations 1 and 3. The resulting reduction in the population size (-18%) is slightly higher than the sum of the isolated effects of 1 and 3 (-16%).

#### 7. Hunting Loss of 1,000 Cranes Annually Plus Reducing the Productivity to 80% (Figure 2G)<sup>1</sup>

Here the combined disturbances result in a decrease equivalent to the sum of both isolated effects.

#### 8. Productivity Increased to 120% (Figure 2H)

If a management effort could succeed in increasing productivity each year by 20%, the benefit for the population would be an increase of only around 8%. This result is again due to the density-dependent regulating capacity of our population model. Interestingly, prior to stabilization of the population, there is a period of around 5 to 10 years of high oscillations — both in percentage of juveniles and in population size — which was almost absent in the case of an equivalent reduction (simulation 3 and Figure 2C).

#### 9. Productivity Increased to 150% (Figure 2I)

This increase is too high for the population to reach stabilization, either in number of birds or in percentage of juveniles, given the relatively small self-regulating capacity imposed by the survival equation in our model (i.e.,  $S_m/S_M = 0.9$ ). Values of  $S_m/S_M$  smaller than 0.9 (i.e., a higher self-regulating capacity for the population) would allow a more rapid stabilization.

#### 10. Survival Reduced to 90% for 10 Years (Figure 2J)

The population would become virtually extinct, as in simulation 5. Interestingly, the result of this simulation is not similar to that of simulations 1 and 2 (hunting). In the hunted population, survival increases — as a consequence of the density-dependence of both survival and productivity — as the total number of birds decreases, while in the present case the possibility of survival rates to compensate for the simulated situation is suppressed by the very terms of this simulation.

#### 11. Survival Reduced to 90% Plus Productivity Reduced to 80%, for 10 Years (Figure 2K)

This is a combination of simulations 3 and 10, representing a general deterioration of environmental conditions,

during breeding and also through the rest of the annual cycle of the birds. Again, the result would probably be the extinction of the population.

#### 12. Catastrophe: 10,000 Cranes Killed (Figure 2L)

If a portion of the crane population were killed as a consequence of an accident, this model predicts a rapid recovery and stabilization at the original population level. This recovery, however, appears too fast to be true in a natural crane population, for which the most realistic result of such an event would be the virtual extinction of the population. As the rapid recovery of the population after a perturbation results from the high stability of the model, being closely dependent on the density-dependence survival function, the parameters defining this function should be reexamined.

#### 13. Influence of Age of First Breeding (Figure 2M)

If the age of first breeding were six years, instead of the assumed four years, the change would only be a stabilization of both the population size and the percentage of juveniles at lower levels (around 10% lower). In the case of first breeding at three years the stabilization levels would be about 5% higher.

### DISCUSSION

The simple model developed should be considered, together with a previous draft (Alonso et al. 1986a), as a first attempt to describe the common crane population dynamics. The series of combinations of values presented in this paper (Table 2) do not exclude the possibility that other equally valid parameter combinations exist. The main limitations of the model derive from the difficulty in obtaining demographic data in the field. This limitation is not only due to the difficulty of accurately measuring demographic variables in wild populations, but also because of the long series of annual data necessary. This problem is especially true in the case of mortality rates, for which only crude estimates are available from recoveries of banded sandhill and whooping cranes, as well as for other long-lived bird species.

In our opinion, one of the short-comings of our model is the rapid response of the population to perturbations affecting the total number of birds, i.e., its high stability. Wild crane populations probably have a lower ability to recover from perturbations increasing mortality, and the effects of such perturbations last for a longer time than our model predicts. The rapid recovery is probably a consequence of the high sensitivity of the density-dependent survival function, determined by the high magnitude of the difference between upper and lower asymptotes of the inverse logistic curve. Indeed, the models developed for sandhill cranes differ mainly in the relative importance given by their authors to the density-dependent regulation of survival rates. While some authors have proposed models that are highly sensitive to alterations in the density of birds, with

survival increases of up to 30% at lower population densities (Johnson 1979), others use such low values ( $2 \times 10^{-5}$ ) that the effect is almost negligible (Miller et al. 1972; Miller 1974; Miller and Botkin 1974). The importance of both features of the model — the magnitude of the density-dependent effect on survival, and the form of the function (linear, logistic) — is evident when the model is perturbed: a high density-dependent regulation ability enables the population to recover quickly from hunting, while a low density-dependent regulation ability prevents such a quick recovery at even the lowest hunting rates. This variability makes it difficult to predict accurately the effects of human disturbances like hunting. The almost negligible effect of hunting on the population presented in this paper should therefore be interpreted with extreme care.

In the case of the function regulating the density-dependent response of productivity rate, the critical values are much better known. The series of annual recruitment values recorded, together with the data from other bird species, help us model this effect more realistically. In our

model, values for  $R_M$  (= maximal theoretical recruitment rate, or upper asymptote of the density-dependent inverse logistic function) below 0.1 (i.e., less than 10% juveniles produced yearly) result in the extinction of the crane population for every numerical combination of the other five parameters (see also Alonso et al. 1986a). Values higher than 0.2 cause high oscillations in population size and percentage of juveniles. It is interesting to observe that all values of annual recruitment measured in the field in our crane population, and the most realistic values inferred for our species as well as for other crane species, fall within these limits. This not only supports the validity of the model but also suggests similar demographic structures in the various crane species for which population data are available.

In spite of the difficulties, the model presented enables future incorporation of submodels and variables that better represent demographic features or account for new effects, thus providing a basis for future research as well as guidelines for the management and conservation of the European population of the species.

#### ACKNOWLEDGMENTS

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## THE DEMOISELLE CRANE IN THE AGRICULTURAL LANDSCAPE OF THE UKRAINIAN STEPPE ZONE

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### ABSTRACT

Observations on demoiselle cranes *Anthropoides virgo* were made from 1982 to 1984 in the southern part of the region of Saporoshje in the Ukraine. Spring migration occurs from mid March to early April. The density of breeding pairs is 0.307 pairs per 10 km<sup>2</sup>. The nests are situated in rolling fields adjacent to shallow valleys with streams. Average clutch size (29 clutches) is 1.97, the dates of egg laying in 17 pairs are from 20 April to 17 May, most pairs laying in the last third of April. The adults take turns with incubating, and chicks hatch after 28 days. Hatching occurred in 17 nests between 18 May and 14 June, mostly in the second half of May. Adults feed chicks with insects after they have left the nest; both adults lead chicks, but chicks stay more often with the female. Competition for food does not lead to fights among the chicks. The chicks fledge after 58 to 59 days. Mortality of chicks before fledging is estimated at 55.3%. Losses of eggs or chicks are mostly caused by human interference. Eggs rolled from the nest were observed for the first time in cranes. At least one of the two eggs was subsequently incubated, but not until hatching. Autumn migration starts at the end of August and ends in the first days of October.

The demoiselle crane has traditionally inhabited populated and accessible areas of the European U.S.S.R., but information on nesting is scarce and limited to short comments on a few nests found, and on encounters with adult and juvenile birds. These comments date mostly from 70 to 140 years ago (Nordmann 1840; Kessler 1851; Goebel 1879; Moltschanow 1906; Borowikow 1907; Osterman 1912; Sudilowskaja 1951; Kistjakiwsky 1957; Kostin 1983). Data on the biology of the species are limited to short comments (Lyssenko and Leshenkin 1982; Siochin 1982).

The decline of the population of demoiselle cranes over recent years (Red Data Book of U.S.S.R. 1980) calls for protection measures - a complicated task in a breeding area so densely populated by people and intensively cultivated. The study of the peculiarities in the distribution of this species in this area of the European U.S.S.R. and the careful study of the crane's biology appear to be an important preliminary step in the organization of protective measures.

### MATERIALS AND METHODS

From 1982 to 1984, stationary observations were made in an area of 520 km<sup>2</sup> in the south of the Saporoshje region. From 1977 to 1984, short trips were made to other areas of this region.

Observations from a hide in the breeding territories of five pairs were made for whole days on 14, 23, 24, 27 and 30 April, and on 13, 17, 24, 25, 30 and 31 May. These were documented with photos and films and covered the period from the search for a nest site to chicks of 10-12 days of age; the observations total 139 hr 25 min. Excursions on regularly or once only used paths were made from the

cranes' arrival to their departure. On these excursions, stationary observations were made on 12 breeding pairs; 3 more pairs were observed on the way. These observations cover a total of 62 hr 24 min.

### DISTRIBUTION

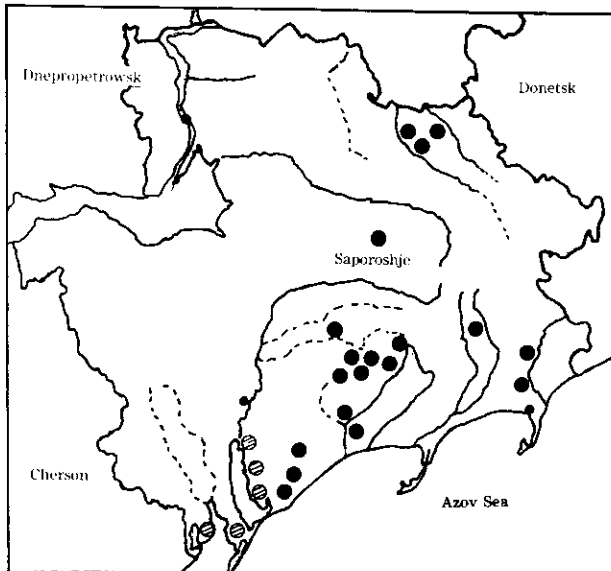
Figure 1 shows the distribution of nests and gathering places for demoiselle cranes from our own observations (17 pairs) or from reliable informants from 1977 to 1984. It shows the data we have collected, not necessarily the distribution of all breeding pairs in this area.

### ARRIVAL AND SPRING MIGRATION

In spring, demoiselle cranes arrive or migrate through this area from about 10 to 20 March. Groups of 4 to 35 birds rest in fields of winter wheat. For example, in 1978 the first demoiselle cranes were seen near the Village of Grolovka on 12 March (33 birds flew in a typical V-formation at a height of 100 - 150 m in a northeastern direction). On the same day in 1979, four cranes were feeding in a field of winter wheat at the Bay of Kubek of the Molotschny Liman and stayed on from 18 to 22 March. In 1984, a group of six birds were observed on fields near the Villages of Nowospasskoje and Makova on 21 March. It is difficult to determine the end of spring migration because many birds that remain in the nesting area for the whole summer make no attempts to breed.

In 1984, two pairs occupied their nesting territories on 4 April. At the same time (7 April), a small group of six birds, probably on migration, were seen near the Village

of Makowa. The end of the arrival of breeding pairs is, we believe, in the first 10 days of April; groups observed after that date are more likely to be non-breeders. On 19 April 1980, 12 birds were feeding in a barley field near the Village of Uspereva, District of Cuilaipole, and on 22 April 1977, 8 birds were feeding near the Village of Manujlovka, District of Primorsk, at a time when the large part of the breeding birds had begun egg-laying.



- gathering places of cranes in autumn
- nest

Figure 1. Distribution of demoiselle cranes in Saporoshje.

#### HABITAT AND DENSITY OF BREEDING PAIRS

The area in the region of Saporoshje is a typical agricultural landscape with flat or undulating fields interspersed with strips of planted forests (mainly *Robinia pseudoacacia* and *Aleditschia triacanthos*), mostly in a north-south direction. West of a line formed by the towns of Saporoshje, Molotscharsk, and Primorsk, the land is mostly flat at a height of 20 - 80 m a.s.l. with only imperceptible valleys and hills. East of this line rise the hills of Priasowsk with many valleys; here we find heights of between 100-300 m a.s.l. While the western area has only one river (the Molotschuaja), there are many rivers in the eastern area. The whole area is almost totally deforested and cultivated.

In the area where we made stationary observations, un-

dulating fields alternate with shallow valleys with small streams and rivers which often dry out by June. On their banks grow reed beds of *Phragmites australis*. Larger rivers with continuous flow are mostly dammed and form a string of little lakes which often have very large reed beds. In the central area of our stationary observations, with an area of 163 km<sup>2</sup> (built-up areas excluded), five, seven, and three pairs of demoiselle cranes nested in 1982, 1983, and 1984 respectively. In those years, their density was 0.307, 0.429, and 0.184 per 10 km<sup>2</sup>, for an average of 0.307 per 10 km<sup>2</sup>.

In choosing a breeding territory, some factors are more important than others.

1) The cranes choose fields close to and often adjacent to depressions or valleys, where there is fresh water and small reed-beds and other natural wetland vegetation - e.g., in the control-area only 58 fields (33.9% of a total of 171) were adjacent to four valleys of various size. No cranes nested on any of 12 fields surrounding one valley. Known nests (n = 14) were in the vicinity of 3 valleys surrounded by 46 fields (26.9% of the total number of fields). The cranes built their nests in 11 different fields (23.9% of fields adjacent to valleys), eight of which were very close to the valley, two across one field at distances of 0.38 km and 0.63 km from the valley, and one across two fields 2.5 km away from the valley. These data clearly indicate the connection between demoiselle cranes' breeding territories and valleys. All uncultivated fields surrounding the valleys were used for grazing from early May: three for sheep, one for cattle.

In the central area of stationary observations, the distances from the edge of a field occupied by a pair of cranes to the edge of the nearest village were as follows: 0.75 km (2 fields); 12.0 km; 1.75 km (2); 2.88 km; 0.63 km; 1.13 km; 1.38 km; 2.13 km; 2.50 km (2); and 1.63 km, for an average (n = 13) of  $2.42 \pm 0.79$  km. The small distances between occupied fields and villages suggest that there is not much difference in human pressure on fields whatever the distance (the specific culture and cultivation methods on each field are probably more important), and that the cranes are not much disturbed by the local population.

2) The cranes chose large, mostly inclined or rolling fields (perhaps this is a general feature of the Saporoshje area). As mentioned before, most of the fields used by cranes fell toward a valley.

During the observation period, 8 of 24 fields adjacent to a valley in the observation area were occupied by cranes. The area of 16 unoccupied fields ranged from 38.7 to 123.5 ha, with an average of  $94.53 \pm 6.05$  ha. The area of 8 occupied fields ranged from 91.1 to 198.4 ha, with an average of  $145.55 \pm 13.98$  ha. A comparison of the average size shows the difference to be significant according to the criteria of Student (with  $p < 0.001$ ). The average area of all 13 occupied fields was even larger at  $158.78 \pm 12.82$  ha.

3) Demoiselle cranes avoid fields with winter wheat, unplowed fields and those planted with perennial fodder-cultures. The vegetation cover of the latter is probably too dense early in the breeding season to appeal to the cranes. The birds clearly prefer barley fields (they are sown before



occupation by cranes, and many grains remain on the surface), fallow fields, and those with late and slow growing cultures or where the individual plants or rows of plants are fairly far apart (maize, sunflowers, castor-oil plants, or Sudan grass). Of 29 known breeding pairs (17 from our own observations, 12 from reliable informants), 10 nested on barley fields, 5 on maize, 3 on sunflowers, 3 on castor-oil plantations, 3 on fallow fields, 2 on Sudan grass, 2 on fields with mixed oat and pea cultures, and 1 on oats. It is interesting that during egg-laying the fields of 14 pairs looked like fallow fields and had no grass vegetation, and the barley on the fields of 10 pairs was only 3-7 cm high. Even though this species has adapted to a highly modified habitat, these data show the cranes' inherent preference for steppe habitats with a thin and patchy vegetation cover. Such habitats were probably typical for all steppe-zones in the southern parts of Europe before cultivation. Such habitats are used by the demoiselle crane in the Asian part of its breeding range, where it is only just beginning to adapt to more cultivated habitats (Koslowa 1975; Kowschar 1982).

The behavior of the cranes while looking for a nesting site indicates that they prefer sites with an open view on all sides. Sites just below the top of a slope are much sought after, the nest-site then being situated in such a way that the sitting bird can only be seen from one side and the top part of the slope hides the body almost completely. Regular, quite dense haze then makes it almost impossible to distinguish the bird.

Distances from the nest to the edge of the field and to the nearest strip of forest were governed by the same preference for open views. While the nearest forest strips of old trees in dense stands were at 200 - 300 m distance, strips of young trees which did not impede the view were often as close as 50 - 100 m from the nest site. Several times we observed adult birds with juveniles, pairs or single birds feeding in new forest strips with widely dispersed trees and with little or no grass cover. Old forest strips with dense undergrowth or those on the tops of hills were never approached any closer than 20 - 30 m. One reason may be that such forest strips are often inhabited by foxes *Vulpes vulpes*.

## NESTS

The nests were from 1.50 - 8.63 km apart, on average (11 distances between 12 nests)  $4.345 \pm 0.9$  km. The nests measured 28 - 39 by 30 - 40 cm, on average ( $n=15$ ) 32.6 by 35.0 cm; sometimes the edges were not very clearly defined, trampled firm by the birds' feet. At 10 sites, we found pieces of dry, herbaceous vegetation scattered about the edges and collected from near the nest. One nest had a 2 - 3 cm thick lining of such vegetation with a diameter of 39 cm. Four sites had no lining whatsoever, one had a few green blades of barley which the bird had picked about 30 cm from the site. We collected all the materials from two nests. In the first nest, the lining materials weighed 68.65 g and consisted of the following: 1) remains of herbaceous plants (28.8 g): a) stems, shoots, roots, and two

fruit-stems of *Xanthium* - a total of 47 specimens, 5 - 22 cm long, 1.5 - 11.0 mm thick; b) stems, roots, and shoots of *Basbasa vulgaris* - 11 specimens, 4 - 20 cm long, 2.0 - 6.0 mm thick; c) stems and blades of grasses - 44 specimens, 2 - 16 cm long, 1.5 - 2.0 mm thick; d) parts of maize leaves - 3 specimens; and e) parts of herbaceous plants - 73 large pieces, 1 - 5 cm long, 0.6 - 5.0 mm thick; 58 small pieces, 0.5 - 2.5 cm long, 0.5 - 2.5 mm thick; and 2) 22 pebbles of feldspar, granite, and quartz weighing a total of 39.85 g (the five largest ones weighed 13.9, 5.4, 3.4, 3.3, and 2.5 g; smaller pebbles weighed around 0.2 g). The lining of the second nest weighed a total of 56.75 g and consisted of 281 individual pieces: 1) parts of stems and roots of sunflowers: 24 larger pieces (10 - 25 cm long, 4.0 - 17.0 mm thick) and 237 smaller pieces (3 - 8 cm long, 1.5 - 10.0 mm thick); 2) 4 pieces of the stems of *Xanthium* (2.5 - 5 cm long, 2.0 - 4.0 mm thick); and 3) 16 pieces of grass blades.

The nest sites of 13 pairs were situated between plant rows or on bare soil, 2 pairs had their nests on rows of barley flattened by the sitting bird but still growing.

## EGGS

Only one of 29 full clutches (15 from our own observations, 14 from informants) had one egg; all others had two. The average clutch size was thus 1.97. The eggs of 15 pairs measured 78.1 - 91.3 by 48.8 - 56.1 mm, on average  $83.10 \pm 0.54$  by  $53.03 \pm 0.45$  mm. The weight of the eggs at various stages of incubation (25 eggs from 13 nests) was 102.8 - 144.3 g, on average  $124.05 \pm 2.41$  g.

We then analyzed the differences in size and weight between the eggs within clutches (from 14 clutches). The difference in length was 0.02 - 5.5 mm, on average  $1.89 \pm 0.46$  mm; in diameter 0.1 - 2.7 mm, on average  $1.11 \pm 0.21$  mm; in weight 0.5 - 10.5 g, on average  $5.41 \pm 0.89$  g.

We compared the egg size of birds which used the same or an adjacent field in two successive years, to find clues about the identity of the female (the birds were not marked). For this we used the following data:

1) In 1982 and 1983 one pair had their nest on the same field in our area of stationary observations (the nest of the nearest other pair was 8.63 km away). Average egg size was: 1982 - 83.75 by 55.50 mm; 1983 - 82.15 by 55.15 mm; an index difference of 1.6 and 0.35 mm.

2) In 1983, one pair changed their nest site and used a field which bordered on the same ravine, but from the other side, at a distance of 0.65 km from the former nest site. Average egg sizes were: 1982 - 78.70 by 50.80 mm; 1983 - 80.10 by 51.05 mm; an index difference of 1.4 and 0.25 mm.

The difference in egg size of these pairs in successive years is smaller than the average difference between the two eggs of one clutch. The clutches from two successive years on these fields were probably laid by the same females.

3) In 1983, one pair changed their nest site to a field adjacent to the previous year's and in 1984 returned to the old site of 1982. Average egg sizes were: 1982 - 80.30 by 49.75 mm; 1983 - 83.70 by 54.50 mm; 1984 - 83.55 by 51.15

mm; the index differences were 1982/83 - 3.40 and 4.75 mm; 1983/84 - 0.15 and 3.35 mm; 1982/84 - 3.25 and 1.40 mm. It is likely that the clutches laid on this field in three successive years were produced by different females, or else the size of the eggs produced by the same female in different years varies considerably more than within one clutch.

Weighing of four eggs from two clutches at different stages during incubation showed that between day 1 and day 27 (egg-shell cracks) an egg loses between 13.38 and 15.32% of its original weight, on average  $13.96 \pm 0.53\%$  (Table 1).

Weight in g		Weight loss		
at laying	at hatching	during incubation		on average per day, in g
		total in g	% of initial weight	
142.5	123.0	19.5	13.68	0.75
136.0	117.8	18.2	13.38	0.70
144.3	122.2	22.1	15.32	0.85
133.4	115.5	17.9	13.47	0.69

Table 1. Weight loss of demoiselle crane eggs during incubation.

We compared the egg size of 15 breeding pairs of demoiselle cranes in the Saporoshje area. The eggs formed two groups according to size (see Figure 2). A comparison of the basic parameters of eggs from the two groups showed that the variations of the average egg length were significant according to Student (with  $p < 0.05$ ) and did not exceed the length of diameters (variations of average significant at  $p < 0.001$ ).

If the measurements of the small group (eggs with smaller diameters) are not entirely chance, then it may be hypothesized that in this group egg sizes are typical for older females; in the large egg group, eggs are typical perhaps for females that breed for the first time. The coefficient of variation (CV) among the eggs of one clutch is 3.69 times smaller in the small group than in the large one. Older females are probably better adapted to the local environment than young ones which lay eggs whose production requires more energy from the organism. Young females, therefore, react more strongly to the state of the trophic base in spring, laying clutches with a higher variation of egg size.

The shells of demoiselle crane eggs ( $n = 29$ ) are greenish (12 eggs) or light olive (10); less frequently, they are greenish-bluish-olive brown (2), olive brown (2), cream olive brown (1), dark olive brown (1), or reddish olive brown (1). In one clutch, the background colors of the two eggs were different: on one egg it was cream olive brown, on the other dark olive brown. On these backgrounds, two types of speckles (1 by 1 mm and 6 by 4 mm) were found in the following combinations (the first type of speckle is superficial, the second is deep): light or yellowish brown and reddish or light reddish gray brown (12 eggs); light ochre or rusty brown and brown or gray brown (10); ochre

and light grayish brown (2); ochre and grayish livered brown (2); reddish brown and grayish brown (2); light rusty brown and dark rusty gray brown (1). The eggs were relatively evenly speckled, but toward the infundibular pole the speckles were more dense, often forming a "cap" (14 eggs), a ring (11 eggs), or a broad belt next to the pole (4 eggs). In one clutch, one egg had a cap, the other a ring. On most eggs (23), there were twice as many superficial speckles as deep ones; only 2 eggs had more deep speckles, and on 4 eggs, there were equal amounts of both types. The density of the pattern (relation of area of pattern to total area of shell, in%) was determined according to the diagram of J. W. Kostin (1977), and came to 15 to 20% (9 eggs), 20 to 25% (12 eggs); 25 to 30% (8 eggs). In two clutches, one egg had a pattern density of 15 to 20% while the other egg had 20 to 25%. The dull shell of the fresh eggs acquires a greasy gloss during incubation. The egg shape according to terms used by Makatsch (1974) was normal oval (23) or elongated oval (6). It is interesting that because of frequent rain in 1983 and 1984 many eggs were covered with a layer of mud up to 1 mm thick in places.

Eggs were several centimeters apart in the nest, lengthwise side by side, but with their infundibular poles mostly opposite each other.

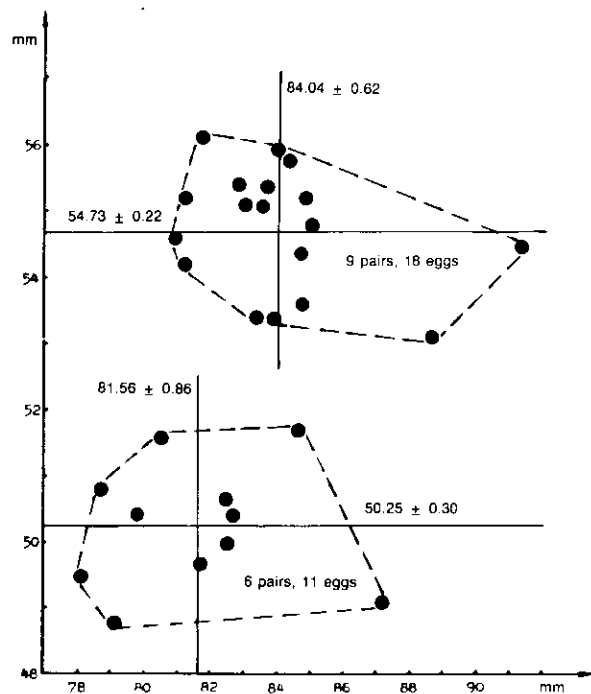


Figure 2. Dimensions of demoiselle crane eggs in the Saporoshje area.

## NESTING

### Pre-nesting Period

It is easy to spot pairs among migrating groups of demoiselle cranes or groups that have just arrived in their

breeding area, and also among groups of non-breeders which spend the summer in the breeding area.

After arrival, the cranes stay in groups, but as early as in the first 10 days of April most pairs occupy breeding territories. In 1984, this happened on 4 April with two pairs and within 10 days one of them had chosen the nest site. On 14 April, the birds spent 552 min of the daylight hours in their breeding territory; the female spending 55 min, the male 13 min searching for a nest site. Such searching behavior looked somewhat similar to the turning of the eggs during incubation: (1) the female treads from one foot to the other, bows forward, lowering the head to the ground and treading round in a circle of a 0.6 - 0.8 m radius with her lowered head at its center. After having trodden one to four full circles, the female (2) sits down (as on eggs), carefully looks around turning the head left and right; then (3) she gets up again, treads from one foot to the other and (4) later she preens herself for several minutes. Such searching behavior was observed between 0918 and 1925; during this time, the female sat six times on the ground (four times a.m., twice p.m.). The male sat down once (probably in imitation of the female, he did no treading before). The female's treading lasted each time between 30 sec and 4 min; she sat down looking around for 2 to 18 min, on average 9 min 10 sec. Three times the female was treading for up to 6 min without afterward sitting down. The greatest distance between "sitting places" was 150 m, but she sat three times in an area of 10 by 10 at various time during the day (and this was later the nest site).

Another breeding pair was observed on 24 April 1983 from 1150 to 1415. This pair already had a nest and both birds were feeding and preening close by for a long time. At 1216, they flew 200 m, coming down 15 m from a sparse forest strip where they were feeding for 2 min before preening for 3 min. Then, at 1222, they copulated for 5 to 7 sec, 66 to 68 hr before the first egg was laid in the nest; they then preened again for 2 min and afterward were feeding close by for 1 hr 25 min. Both eggs were laid in the morning (before 1050 on 25 and 27 April) at an interval of 48 - 50 hr.

In 1984, the period between occupation of a breeding territory and the laying of the first egg for 2 pairs was 16 and 27 days respectively.

#### Incubation

Egg laying occurred in 17 pairs on the following dates (observations and extrapolation): April 20 to 22 (3 pairs), 21 to 23, 22 to 24 (2 pairs), 23 to 25, 24 to 26, 25 to 27 (3 pairs), 26 to 28, 30 April to 2 May, May 1 to 3, 6 to 8, 14, 15 to 17. Thus 75.8% of the eggs were laid in the last ten days of April, others in the first half (up to 17) of May.

Two pairs started incubating after the first egg was laid. In the first week of incubation (3rd, 4th and 6th day, on 24, 27 and 30 April 1983), the birds of two pairs incubated during 85.7 to 89.9% of daylight hours, on average 87.2%. The female did 36.6 to 73.9% of the incubating, on average 59.0%, the male the remainder. The birds changed incubating duties 5 to 15 times during the day, an average

of 10 times. One incubation sitting lasted on average 20.0 to 197.0 min for the female (average 66.9 min), and 15.0 to 69.7 min for the male (average 52.5 min). Disturbance affected the incubation periods very much. Great disturbances (i.e., people entering the breeding territory) led to the birds' leaving the nest for various periods. When brief disturbances occurred at short intervals, the birds kept changing incubation duties frequently for a long part of the day. Smaller but longer lasting disturbances (i.e., tractor working all day on an adjacent field) had a similar effect.

The birds changed the position of the eggs every 36.3 min and changed incubating duties every 75.4 min during daylight hours. The female turned the eggs over more frequently than the male (every 67.3 min against every 78.5 min). During this period, the male spent three nights, and the female two nights on the nest.

The first changeover of the day took place between 0707 and 0936, the last between 2012 and 2037. The eggs were turned the first time between 0707 and 0743, the last time at the last changeover.

In the last week of incubation (22nd, 23rd, 24th day; 13 and 17 May 1983 and 25 May 1984), the birds of three pairs incubated during 44.0 to 93.1% of the daylight hours, on average 72.0%. The female did 34.8 to 59.8% of the incubating during daylight hours, on average 45.6%, the male the remainder. The birds changed over duties 10 to 15 times during the day, on average 12.3 times. The length of one "sitting" was 14.0 to 63.1 min for the female (average 41.1 min), 28.8 to 72.0 for the male (average 46.3 min).

During the day, the birds changed the position of the eggs every 50.8 min. The male turned them much more frequently than the female (every 77 min against every 149.5 min). During this period, the female spent four of five nights on the nest, the male one.

The first changeover of the day now took place between 0603 and 0744, the last between 2112 and 2134, the eggs were turned the first time between 0603 and 0650, the last time at the last changeover.

Part of the change in the incubation schedule is due to the increased day length. The shorter incubation time and less frequent turning of the eggs may be due to normal changes in the incubation schedule, but they must be seen against a background of sharply increased agricultural activities and increased disturbance which doubtless leads to more frequent changeovers at the nest.

#### Hatching

Observations of the hatching of the chicks from one nest (from 1810 on 22 May to 1840 on 25 May 1983) showed that the adults did not change the position of their eggs after the 25th day (and night) of incubation. As the first cracks appeared in the eggshell, the chick was turned inside the egg in such a way that the first holes developed where two cross cuts intersect; one vertical through the egg axis, the other horizontal one quarter length from the infundibular pole. The shell was opened from left to right or counter-clockwise (looking from the "blunt" pole). The chick began to chirp inside the egg 7 - 8 hr before the first cracks ap-

peared, 50 - 53 hr before it had hatched completely. Cracks and holes appeared in the shell on the 27th day after the first egg was laid, the 26th day after the second egg was laid. Both chicks were hatched completely on the 28th day after each egg was laid. The interval between the appearance of the first cracks and complete hatching was 32 - 34 hr and 43 - 45 hr respectively, and between the appearance of cracks in the two eggs of this clutch the interval was 31 - 32 hr. The time between the full hatching of the two chicks was 41 - 43 hr. Thus, it took 74 - 77 hr from the moment the first egg cracked to the full hatching of the second chick.

Both chicks hatched between 1200 and 1500, during the warmest period of the day. After 5 - 6 hr, the down on the chicks had dried completely.

Chicks hatched on the following dates: 18 to 20 May (3 pairs); 19 to 21 May, 20 to 22 May (2 pairs); 21 to 23, 22 to 24 May; 23 to 25 May (3 pairs); 24 to 26, 28 to 30, and 29 to 31 May; 3 to 5, 11, and 12 to 14 June. Of 33 chicks, 28 hatched in the second half of May.

#### Egg Shells

In the 1 - 7 days after the chicks had left their nest, small pieces (up to 5 mm long) of egg shells remained on 12 nest sites. The following observations describe what had happened with the remainder of the egg shells.

When we visited the nest during the absence of one adult and the two-day old chick and while the other adult was incubating the remaining egg, we noticed that there were no egg shells in the nest. The cranes were certainly involved with their disappearance, since even birds that had left their nests, after being disturbed, watched their nests carefully from the air and chased rooks *Corvus frugilegus* venturing too close to the nest. At another nest under observation from 0550 to 1925 on 31 May 1984 (a nest with a 1.5 day-old chick and an egg), the adults fed the chick exclusively on small pieces of the egg shell that lay beside the nest from 0609 - 1156, then the chick left the nest. We observed the female doing this seven times, the male twice. Later that day, the adults led the chick twice back to the nest and fed it again with egg shell. At a third nest, hardly anything remained of the egg shell 6 hours after hatching. But 36 hr later the "blunt" pole of the first egg's shell was discovered 6 m from the nest in a dense cluster of barley approximately 30 - 35 cm high.

Adult demoiselle cranes do, therefore, feed the egg shells to their chicks. In some situations, however, they remove shells from the nest (disturbance was a factor in one nest: when the first chick hatched, barley was being harvested on an adjacent field). It is interesting that in all five nests of red-crowned cranes *Grus japonensis* (Winter 1977) and in a nest of the common crane *Grus grus* observed near Leningrad, both in similar situations to the demoiselle crane nests in this study, the shells of both eggs remained in the nests.

#### Development and Rearing of the Chicks

Five to six hours after hatching, a chick that was barely dry tried to lift its head. When it tried to get up on its feet,

it fell over. Two breeding pairs kept their first chick under their bodies for longer than the first day and night. In another pair, the adults hardly warmed the second egg during hatching once the first chick had left the nest; in yet another pair, one adult stayed with the first chick while the other sat on the nest.

One pair was observed on the day the chick left the nest (from 0550 to 1925 on 31 May 1984). The chick was 24 hr old and still in the nest; the adults offered it pieces of egg shell that it could only take at the third or fourth attempt since its pecking was so inaccurate. When the parents were away defending the territory, the chick in the nest began to chirp loudly; normally it would make short chirping noises almost continually every 5 - 7 sec. After 25 - 30 hr, it tried its first shaky steps, falling over often. After it had left the nest, one adult stayed with it all the time. Only now the adults started feeding the chick with insects that they snatched from the ground or from the vegetation. About every 50 - 80 min, the female sat down to warm her chick for 10 - 15 min; in the morning and evening, she did this more often than during mid day. During this day, the chick walked slowly on a radius of 20 - 40 m, about 28 - 30 m from the nest.

Adult demoiselle cranes that accompany chicks make purring noises similar to a cat, but louder and in a lower tone. These noises are produced every 5 - 7 sec and are a little like the clucking of a hen. Similar behavior is known from red-crowned cranes (Winter 1977). If they are disturbed, the adults produce a louder irregular purr, a "rrrooo...rrrooo." During observation from a hide at a greater distance from the nest (40 rather than 11 m), these noises could not be heard. They probably serve as contact signals among the parents and chicks, and other birds or enemies don't hear them.

Until they were three days old, chicks did not hide but tried to run away when they saw people approaching. Five-day-old and older chicks lay totally still, often in an awkward position (e.g., on a clump of earth) when they were discovered. Obviously, they "froze" wherever they happened to be on hearing a warning from their parents. When such a chick was released, it ran away 5 to 25 m before "freezing" again. All chicks held out their wings horizontally at hack height when running away from people.

One pair with 10 - 12 day old chicks was observed in their breeding territory on 31 May 1982 from 0410 to 1523. The territory was a large field (250 ha) through which ran a shallow stream; the stream had reeds growing along its banks and other typical wetland vegetation. The crane family roosted in the reeds, the tallest stalks of which were about 10 - 15 cm taller than the cranes. The female warmed the chicks overnight and three times in the early morning (between 0610 and 0835) for 9 - 13 min each time. Between sunrise and 1523, she warmed them for a total of 85 min (14.8% of the total time), the male taking no part in this. The largest part of the feeding time (66.4% was spent by the whole family in the meadows along the stream; less feeding time (33.6%) was spent in maize cultivation where the seedlings were 10 - 15 cm high and 1 m apart.

Male and female have different functions in the rearing of the chicks. When the birds were undisturbed (not more than 1/10 of the observation period), each adult was leading one chick. The male was in front, the female 3 - 6 m behind. When the male was disturbed, it walked faster increasing the distance from the female to 15 - 20 m; the chick it was leading stayed behind and joined the female. Such situations occurred frequently, so the chicks were with the female for the greater part of the time. They stayed parallel with the adult, one to each side of its feet. When they walked behind the female, they were often so close together as to touch each other, but sometimes they were 0.5 - 1.0 m apart. Every few minutes, the adults would snatch some insects from the vegetation, sometimes from the ground, then it would stand still, turn its head backward and down to one side and would offer the insect to one of the chicks. The chick would come, pick up the insect, and eat it at once. The male offered 1 of every 2 to 3 insects to his chicks, the others he ate himself. Twice during the observation period, the male suddenly chased some nearby hooded crows *Corvus corone cornix* and rooks.

The female did not pick up food insects but pecked at them repeatedly; the chicks then came running to pick the food item up; without the female "indicating," however, the chicks did not peck at any insects and did not come running. A race for the indicated food occurred 150 times during the observation period, but there was never any fighting for food seen between the chicks. During a period of 65 min (0835 to 0940), the chicks raced 23 times to be the first to get food indicated by the female. Calculations on the frequency of feedings show that the cranes were feeding 2.0 to 2.3 times more often in the meadows near the stream than in the fields. Taking into account the time spent in the two areas, it became evident that the birds collected only 20% of their food in the fields, the remainder in the meadows near the stream. The reed beds near the stream acted as an important cover; whenever danger threatened (appearance of tractors or people in the field), the adults led their chicks into the reeds, watching for several minutes from places where the reeds were as tall as they were. When they had calmed down, they crossed the stream and continued feeding on the other side. Such a situation occurred three times during our observations. If we add here our observation that during incubation the birds often flew to the stream to drink after a changeover at the nest, then it becomes clear why the cranes prefer fields adjacent to a valley with a stream for a nesting site.

How long a family remained in their breeding territory often depended on disturbance. Almost all families remained in their breeding territory until the chicks were two weeks old, some even longer; others moved to nearby fields that were close to a stream. On the day of our observation, the pair with 10 - 12 day-old chicks moved to an adjacent field at 1410 after cultivating had started on their breeding territory at 1200; two days later, they were seen by the stream 2.5 km from the nest site. In 1984, one pair stayed near the stream adjacent to their breeding territory until the chicks were 27 days old;

another pair remained in the same field until the chicks could fly.

Observations of one pair showed that the chick flew at an age of 58 - 59 days.

#### Nesting Success and Mortality

The fate of the broods was monitored from the laying of the eggs to the end of May. Of 33 eggs (100%) from 17 nests, 24 chicks hatched (72.7%) in 14 nests, and of these 21 chicks (63.6%) survived to the end of the month. There are only sightings to document their further fate: in the second half of June, 8 families were seen with a total of 11 chicks, and in July, 6 families were observed flying a total of 8 juveniles. To make calculations with these observation data, we take the data from the end of May (21 juveniles of 13 pairs) as a basis ( $n^{\text{initial}}_{\text{juveniles}}$  and  $n^{\text{initial}}_{\text{pairs}}$ ) and calculate the survival of juveniles to the end of June ( $X_{\text{VI}}$ ) with the following formula:

$$X_{\text{VI}} = \frac{n^{\text{initial}}_{\text{pairs}} \times n_{\text{juv. VI}}}{n^{\text{initial}}_{\text{juv.}} \times n_{\text{pairs VI}}} \times 100 = \frac{13 \times 11}{21 \times 8} \times 100 = 85.4\%$$

This means that the number of chicks of all 17 pairs surviving to the end of June ( $n^{\text{I}}_{\text{juv VI}}$ ) was:

$$n^{\text{I}}_{\text{juv. VI}} = \frac{n^{\text{initial}}_{\text{juv.}} \times X_{\text{VI}}}{100} = \frac{21 \times 85.14}{100} = 17.88$$

and the number of pairs that still had chicks at the end of June ( $n^{\text{I}}_{\text{pairs VI}}$ ) was:

$$n^{\text{I}}_{\text{pairs VI}} = \frac{n^{\text{initial}}_{\text{pairs}} \times X_{\text{VI}}}{100} = 11.07$$

Using similar calculations for flying juveniles, we get the figures of 14.76 juveniles from 9.14 pairs (of the initial 17) surviving until they can fly. Overall calculations of the breeding success of the reproductive part of the demoiselle crane population show the following: in 17 nests, 33 eggs (100%) were laid, 24 chicks (72.7%) hatched in 14 nests; 21 of these (63.6%) survived to the end of May in 13 pairs; at the end of June 11.1 families still had 17.9 juveniles (54.2%) and in July 14.8 juveniles (44.7%) in 9.1 families started to fly. The mortality before fledging was therefore 55.3%. This is probably smaller than the true figure since it was not possible to include all lost eggs or pairs that lost both chicks in our calculations without marking the adults. The destruction of four clutches with 7 eggs was discovered before 13 to 17 May, and 40% of the clutches were found after 13 May; some of the destroyed clutches have, therefore, not been included in the calculations.

Of the calculated 18.2 eggs and chicks that did not survive to fledging, the cause of death is known for 11 (60.3%). Eight eggs from five clutches did not hatch. Four eggs from

three clutches were destroyed by natural causes: a) one clutch was destroyed in the first week by wild boars that approached the nest during the night and ate the eggs, shells and all; b) in 1984, one egg rolled out of each of two nests. In at least one case, the adults probably incubated each of their two eggs alternately, but then abandoned one egg and incubated only the other (see below).

Direct human interference was the cause of destruction of two nests with four eggs; they were squashed during cultivation of the fields on 13 and 17 May respectively.

Human disturbance was the indirect cause of death of three chicks of three pairs: a) young nestlings in two nests were killed by rooks or other corvids because their parents had left the nest with the older chick to avoid disturbance by agricultural activities nearby (on 25 and 31 May); b) one chick was killed by a sheep dog at the age of 18 to 20 days (on 9 June).

#### Eggs Rolling Out of Nests

This occurrence has not been reported in cranes before. When we visited the first nest on the 17th day of incubation (8 May 1984), one egg was in the nest while the other was 70 - 75 cm away on a slightly trampled site where barley stalks had been flattened but no lining was found. This second site was in a furrow about 50 cm wide and 10-13 cm below the level of the nest. The hard shell of the second egg was pecked through in one place and the mud on the shell showed deep scratches made by a crane bill. On the day before our visit, the first egg in the proper nest was incubated. The last heavy rain had occurred on 29 April (9th day of incubation), later it had been dry. Since both eggs were similarly muddy, we assumed that during the first 9 days both eggs had been incubated in the nest. The bill marks in the dry mud on the second egg show that it could not have rolled out of the nest before the 10th or 11th day. The birds thereafter incubated the egg in the nest; the flattened barley stalks indicate that at least occasionally in the first days after rolling out they also incubated the second egg.

When we visited a different nest on the 22nd day of incubation (23 May 1984), it looked very similar; the two eggs were 1 m apart, the site with the lining was in a slight ditch and its level was 5 to 6 cm below that of the other egg's site. Both eggs were undamaged, but on the day of our visit, the adults only incubated the higher nest (without lining). This egg was warm and obviously incubated since its shell looked greasy and glossy; the other egg was probably not incubated, as it was not glossy and looked dusty. This egg looked "dead" (the eggs had been laid on 2 and 3 May in dry weather and their shells were clean). We put the unincubated egg next to the incubated one, but after the older chick had left the nest (on 31 May) the adult did not incubate any more and the remaining egg showed no signs of hatching. It is interesting that in both instances the birds chose to incubate the longer egg of the two which was situated in a higher nest.

These observations suggest the presence of an autoregulatory mechanism that controls the number of chicks a pair of demoiselle cranes raises, similar to those

described for European white stork *Ciconia ciconia* and eastern white stork *Ciconia boyciana* (Siewert 1932; Winter 1978). We shall now describe the peculiarities of the climate in the 1984 breeding season that may have triggered this mechanism.

The spring season of 1982 and 1983 were rather similar in character and timing and much like many spring seasons of previous years, except that in 1982 there was hardly any rain at all and in 1983 there was constant light rain on 5 and 7 May and about one hour's rain on 6 and 8 May. These rains were not accompanied by persistently low temperatures. The second half of March and first half of April 1984 were not very different from the previous years' seasons. The numbers of breeding pairs were similar to the last year's and until mid April, the crane pairs occupied their breeding territories. From 16/17 April on, it became colder and from 19 - 29 April, it rained almost every day; the combination of heavy rain and low temperature slowed down vegetation growth by about 10 to 15 days and adversely affected the increase of insect populations in April and May. Heavy rainfalls caused agricultural activities to start much earlier than usual (from 22 April onward), and these went until mid May. Some cranes left their breeding territories, others had their clutches

Date	Number	Location
Near breeding areas:		
6 September 1979	3	Makowka
15 September 1979	7	Panfilowka
20 September 1984	12	Panfilowka
29 September 1981	12	Panfilowka
Coast of Azov Sea and adjacent area:		
1 September 1983	8	Konstantinowka
1-10 September 1979	22	Girsowka
5 September 1980	12	Girsowka
7 September 1983	15	Konstantinowka
11 September 1980	7	Girsowka
11 September 1980	6	Girsowka
12 September 1983	8	Kirillowka
13 September 1983	14	Konstantinowka
16 September 1981	18	Girsowka
16 September 1983	5	Girsowka
17 September 1982	11	Girsowka
19/20 September 1980	9	Utlug-Liman
20 September 1982	6	Girsowka
20 September 1983	17	Girsowka
22 September 1981	13	Girsowka
22 September 1983	23	Konstantinowka
24 September 1983	10	Girsowka
26 September 1981	11	Girsowka
28 September 1982	12	Girsowka
28 September 1979	27	Girsowka
29 September 1981	22	Girsowka
30 September 1983	27	Girsowka
30 September 1983	30	Konstantinowka

Table 2. Migrant demoiselle cranes in the Ukraine.

destroyed. This created large numbers of non-breeders and increased the number and intensity of their conflicts with nesting birds. The combination of adverse weather conditions and an unusually strong disturbance factor in 1984 meant that in the area of stationary observations, only three pairs nested where in 1982 and 1983 eight pairs had done so. It is possible that this increased disturbance has caused the loss of eggs through rolling out of the nests.

#### FORMATION OF FLOCKS AND AUTUMN MIGRATION

It is difficult to detect the initial stages of flock formation before autumn migration, since non-breeding birds, after spending the spring and early summer months in nesting territories, form flocks of four to six birds by the end of June. The size of these flocks varies during the summer months because they are joined by birds whose broods have failed.

In the first weeks of July, flocks of 7 to 11 Demoiselle

Cranes are quite common in areas away from breeding territories (e.g., 6 to 7 July 1982 near the Village of Nowokonstantinowka). In August, small groups of adults and juveniles are still near the breeding territories (5 August 1984, four birds near the village of Gromowka; 25 August 1981, six birds near the Village of Kalinowka; 26 to 28 August 1979, five birds near the Village of Makowka).

From September, the largest part of the cranes was seen far from their breeding territories along the coast and adjacent areas of the Azov Sea (see Table 2). Their number increases during September, those departing being replaced by others that arrive to build up their fat reserves for the migration. Occasionally, smaller flocks can be observed which are obviously on migration; they stop to feed or fly past during daylight hours at a height of 100 - 150 m.

The last demoiselle cranes were seen in the first days of October. On 3 October 1979, 37 cranes were feeding on winter wheat at 1400 near the Village of Atmaraj on Utlug Inlet, and at 1830 the flock rose and flew southwestward.

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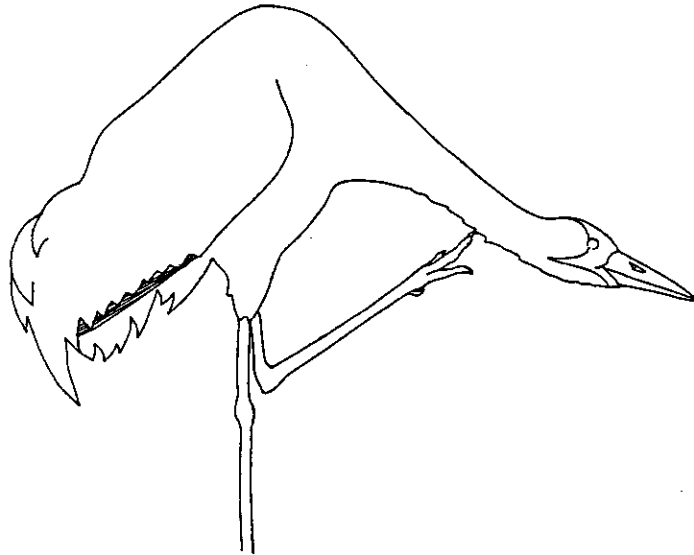
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CHAPTER 9  
JAPAN





# POPULATION DYNAMICS OF RED-CROWNED CRANES IN HOKKAIDO SINCE THE 1950S

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## ABSTRACT

Though the results of official yearly censuses in early December are not always accurate, three stages of population growth of red-crowned cranes *Grus japonensis* wintering in Hokkaido were recognized: (1) a rapid increase until the beginning of the 1960s, (2) an equable stage, and (3) a recent increase since the latter half of the 1970s. The first increase was due to the success of artificial feeding which reduced the mortality during severe winters. The second stage was probably caused not by a decrease of birth rate but by the remarkably high death rate from collisions with electric wires. The loss by collision was 71% of 79 dead cranes found during 1970-74. The mortality rate of juveniles was significantly higher than that of adults and subadults. The recent increase in population is probably a result of lower mortality because of countermeasures to prevent collisions. But in the near future, the restricted extent of suitable breeding grounds in Hokkaido will become one of the greatest limiting factors for the growth of this isolated population.

## INTRODUCTION

The Japanese population of *Grus japonensis* breeding in Hokkaido decreased during the 18th and 19th centuries. Only 30 to 40 individuals remained in the wild marshes of eastern Hokkaido until the middle of this century (Masatomi 1981). After the success of artificial feeding of this isolated population at the beginning of the 1950s, the number of cranes has grown to about 10 times the initial population.

Here I describe the process of population growth since the 1950s and briefly infer the factors affecting this growth.

## RESULTS AND DISCUSSION

### Reliability of Official Censuses

The number of cranes in Hokkaido has been counted every year in early December since 1952 by the local residents and officials. The number of cranes counted, however, does not always indicate the exact population size of the cranes wintering in Hokkaido because of some inaccurate counting methods (Masatomi 1979, 1981). In certain years most of the cranes have gathered at places where people can easily observe them on the census day. In other years, the cranes have been more difficult to observe. The frequent fluctuations of counted numbers are unreasonable, as no immigration and emigration of this species between the continent and Hokkaido are sustained. For example, even if no cranes died between the December 1971 census and the next census, the number of cranes in-

cluding juveniles in 1971 was 48 individuals less than the 1972 total of adults and subadults (Masatomi 1979). Thus I cannot closely analyze population dynamics from these inaccurate data.

### Population Growth

Nevertheless we are able to recognize three stages of population growth from Figure 1: the first rapid increase of cranes through the beginning of the 1960s; the second almost equable stage in the 1960s and early 1970s; and the final definite increase since the latter half of the 1970s. In order to determine the rate of population increase, the mean individual number and the growth percentage were calculated for five-year intervals from 1952-1986 (see Table 1).

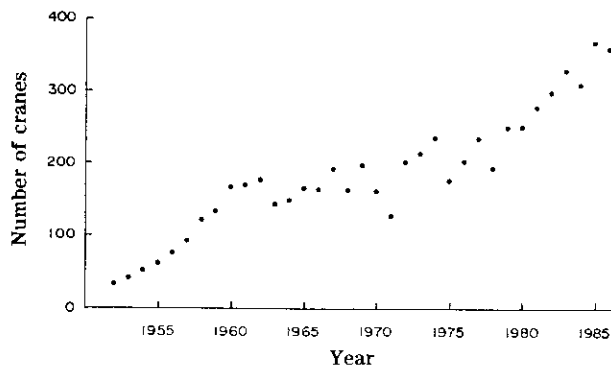


Figure 1. Population growth of red-crowned cranes in Hokkaido, 1952-1986.

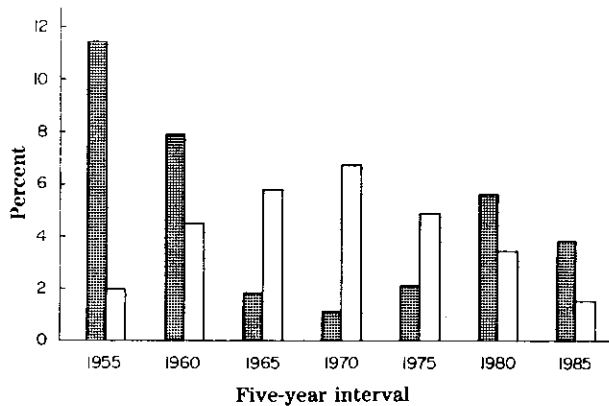
	1952-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84	1985-86
Mean number of cranes	42.3	97.0	160.8	177.4	187.8	210.4	292.2	362.0
Rate of increase <sup>a</sup>	-	229.3	165.8	110.3	105.9	112.0	138.9	123.9

Table 1. Mean number of red-crowned cranes and rate of increase from the previous five-year period. Captive cranes are excluded.

$$^a r(\%) = 100 \times \frac{N_X - N_{X-1}}{N_{X-1}}$$

The number of cranes counted during the latter half of the 1950s indicated a growth of more than two times the original population, which might be considered the natural carrying capacity of this species in eastern Hokkaido.

Although the officially announced results of the December census include the cranes kept in the Kushiro Crane Park and Zoo, the mean rate of annual increase of the population during each five-year term was calculated without including captive ones (see Figure 2). The mean rate of increase was relatively high before the late 1960s (7.9-11.4%) and after the 1970s (3.8-5.6%), but low during the late 1960s and 1970s (1.1-2.1%).



**Figure 2.** Mean rate of annual increase (shaded) and death (open bars) in five-year intervals. Mean rate of annual increase (%) =  $100 (\bar{N}_X - \bar{N}_{X-1}) / \bar{N}_X$ . Mean rate of death (%) =  $100 \bar{D}_X / \bar{N}_X$ .

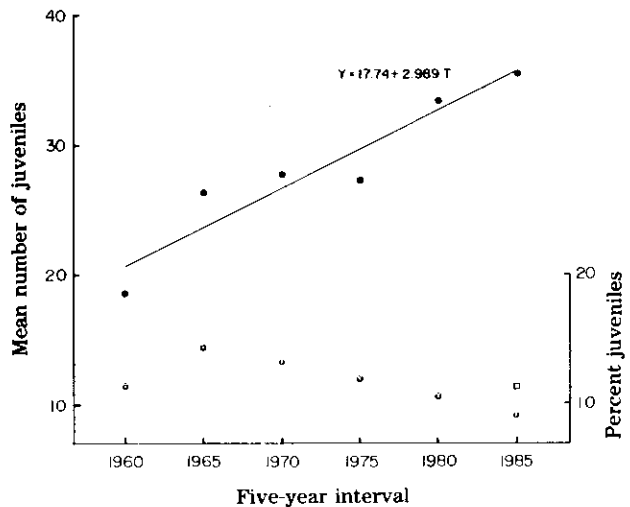
Even if the December counts consistently underestimated the crane population during the second stage, the real growth of this population must have been slow. It is therefore necessary to consider the factors controlling reproductivity of the cranes in Hokkaido.

A low population growth generally results from low natality and/or high mortality. Unfortunately, there is no means by which we are able to determine directly the birth and death rates of the red-crowned crane. Our counts, however, indicate that the mean number of juveniles in each five-year interval gradually rose (see Figure 3). The number of breeding pairs observed from the air and ground also gradually increased from 58 in 1973 to 101 in 1985 (Hokkaido Nature Conservation Section 1986, Masatomi et al. 1986).

At first sight, the crude birth rate of the population seems to have decreased (see Figure 3). But we cannot always rely on the figures: when the percent of juveniles in the population was computed from early February censuses of three recent years (Masatomi et al. 1986, unpublished), the ratio was significantly higher than that calculated from the official censuses ( $P < 0.05$ ). So I hesitate to say that the fluctuation of birth rate deeply affected the trend of population growth.

There is little data available on the percent of juveniles during the first rapid increase of population, but it was very high (25%) in 1954 (Masatomi 1981). The percent of juveniles was lowest (7.2%) in 1975. But the mean rate of annual increase of the total population was still 10.5% during the

most recent seven years. The mean percent of juveniles in the population during the latest three years (1984-86) was 9.2%, as calculated from the December census; but the rate was 11.4% according the February census. The latter is significantly higher ( $p < 0.05$ ) (cf. Figure 3) and more reliable, because in February almost every crane concentrates on a few restricted feeding stations where we are able correctly to count the number of cranes and definitely identify the juvenile. This higher percentage is also similar to the 11.4% population growth of the rapid increase period in the late 1950s.



**Figure 3.** Mean number (shaded circles) and percent (open circles) of juveniles in the red-crowned crane population counted in December, for five-year intervals. The open square indicates mean percent of juveniles in the February census in 1985-86.

#### Mortality

There are no data from which we can determine an accurate death rate. The red-crowned crane, however, has been designated as one of the special natural monuments in Japan; the dead cranes, if they have been found, are collected by the local government. The number of dead cranes registered has ranged from 0-23 per year, and the percentage of the December population has been 0-13.5% (with a mean of 4.3) during the past 35 years (see Figure 4). Although not all dead cranes were picked up every year, the percentage suggests the relative extent of mortality. The mean rate of annual death during each five-year interval is shown in Figure 2: the mortality was low at first, highest in the early 1970s, and then decreased again. This increase and decrease of mortality correlate negatively with the rise and fall of the rate of population growth.

It was probable that the rapid increase of the population during the first stage was because of success of artificial feeding which reduced the mortality caused by the severe winters and corresponding food shortages in the natural habitats (Masatomi 1981).

But what was the most important factor causing the second stage, of low population growth? A total of 145 dead

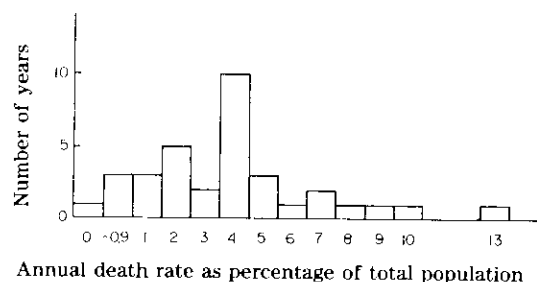


Figure 4. Frequency of annual crude death rate among red-crowned cranes in Hokkaido, 1952-1986.

cranes were dissected by veterinarians from 1969-80 (Hokkaido Educational Committee 1981), and 45.5% of them were juveniles. The death rate of juveniles was very significantly higher than that of adults and subadults ( $P < 0.00001$ ). The high death rate among juveniles suggests that the birth rate might not have been reduced even in the second stage (cf. Figures 2 and 3). Therefore the second period, of low population growth, appears to have been caused primarily by the high death rate. And the recent increase in the population probably results from the reduction of death rate.

Then what were the real reasons for the change in the death rate? The direct causes of death were roughly assigned into the following five categories: collision with electric wires, hunting accidents, trauma, disease, and unknown (Hokkaido Educational Committee 1981). The cause that showed the most outstanding change in number or rate was collision with wires (Table 2). The loss by collision was only 10% of 10 dead cranes during 1955-59, but it was 71% of 79 dead cranes during 1970-74. But losses became noticeably low again: 16.7% of 24 dead cranes from 1983-86.

Why did the death rate by collision with electric wires decrease since the late 1970s? It was probably due to countermeasures such as the attachment of tags or tubes colored with warning stripes on wires, the partial removal or transfer of wires from the artificial feeding places where the collisions happened most frequently, and a reduction in human activities that surprised and caused the cranes to be confused at feeding or roosting places. It is only an assumption that the individual cranes, with poor vision or reflexes for avoiding dangerous wires, have been eliminated from the population in the past two decades.

#### Other Factors

The population growth mentioned above, however, might be controlled not only by the change of death rate through collision with electric wires, but also by other biological and social factors. We should consider the environmental resistances to population growth — including limitation of suitable breeding grounds, density effects of the population, increase of such natural enemies as red foxes *Vulpes vulpes* or minks *Mustela vison*. The low growth of the second stage was mainly due to the high death rate by collision. But it might also be partially the result of the human activities that disturbed the breeding activities of cranes, including direct destruction of their breeding habitats and human activities there in preparation for land developments under the intense economic activities of the 1960s and 1970s. The slow pace of land developments after the oil crisis might correlate with the crane increase since the late 1970s.

The largest limiting factor in the near future, however, is probably the loss of the breeding grounds that are continuously developed for agriculture and other uses. Therefore we should protect the breeding habitats to keep this isolated crane population growing in Hokkaido.

	1952-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84	1985-86
Collision	16.7	10.0	53.9	49.2	70.9	33.9	26.8	8.3
Error in hunting	8.3	10.0	2.5	1.8	1.3	1.7	0	0
Trauma	0	20.0	20.5	17.5	10.1	28.8	23.2	75.1
Disease	66.7	20.0	0	14.0	6.3	15.3	10.7	8.3
Unknown	8.3	40.0	23.1	17.5	11.4	20.3	39.3	8.3
Total number	12	10	39	57	79	59	56	12

Table 2. Causes of mortality (by percent) recorded from 1952-86.

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# CONSERVATION OF THE HOODED CRANE AT YASHIRO, JAPAN

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## ABSTRACT

At Yashiro, Japan, the number of hooded cranes *Grus monacha* gradually increased after 1870, to 355 birds around 1940. But this number has decreased since 1960, and now stands at about 60. Yashiro is located at the western edge of Honshu, the main island of Japan. It is a small basin 300 m above sea level, surrounded by woods. The cranes use primarily paddy fields, very close to the villages. Therefore even slight changes in the villagers' lives affect the cranes. Changes in the feeding places and roosts are examined by comparing observations made in 1961-62 and in 1986. In 1961, there were as many as 26 feeding places, but the number has decreased to only 5 places now. There were 22 roosts in 1961, but now there are only 5. At first roosts occurred naturally, but all current roosts are cleaned and repaired by the villagers in summer. A number of conservation measures have been implemented, and hooded cranes have been registered as a natural monument. Portions of the paddy fields were bought as feeding places; a watchhouse was built. Parts of the paddy fields, the wild plain, and the woods were purchased, where the cranes have their roosts. Weeds in and around the roosts are mowed every summer, and the roosts are filled with water before the cranes come. These measures have not stopped the decline in crane numbers. It is proposed to enlarge the conservation area and otherwise improve conditions for the cranes.

## LOCALITY OF YASHIRO

Japan has only two wintering places for hooded cranes: Yashiro in Yamaguchi Prefecture, and Izumi in Kagoshima Prefecture. About 60 cranes migrate to Yashiro annually. Although 60 cranes represent less than 1% of Izumi's population, Yashiro has a history of over 100 years as a wintering ground.

Yashiro is a small basin 320 m above sea level on tableland in western Honshu. It is surrounded by low mountains with an altitude of 400-700 m and extends 4.5 km east to west and 6.5 km north to south. Rice is the main crop.

Cranes use roosts separate from their feeding areas. These areas are larger than roosts and are found near the center of the basin. Roosts are on wet paddies surrounded by mountains on three sides, with one open side regarded as an entrance. Feeding places and roosts are very close to villagers' houses, to within 100 m, in contrast to habitats used in other countries. Crane life is apt to be interrupted by villagers.

Because the cranes' feeding areas are harvested rice paddies, few serious problems arise between cranes and farmers. Changing agricultural practices and patterns of living, however, are causing the environment to deteriorate.

## THE POPULATION OF HOODED CRANES

About 10 hooded cranes were counted at Yashiro in 1877. They gradually increased to a peak of 355 in 1940 (see Figure 1). By 1960 they had decreased to 132 and in 1980 to 61.

The first cranes arrive at Yashiro between late October and early December. They gradually increase in number and reach their maximum around late January. The earliest arrivals stay for about four months, the latest for about two. All cranes depart in early March within one or two days.

## CHANGES IN THE ENVIRONMENT

### Feeding Sites

A feeding site is defined as a place where cranes feed for more than one week. Sites are spread within a radius of 1-10 km from the roosts. Feeding sites vary greatly, with areas ranging from 1-50 ha. Most feeding sites are harvested rice paddies, where cranes eat the waste rice.

Table 1 shows there were 24 feeding sites in 1971, but in 1981 the number of feeding sites decreased to only six (Kawamura 1975).

Number	1961	1971	1981	1986
Feeding Places	26	24	6	5
Roosts	22	20	7	5
Cranes	108	108	66	57

Table 1. The number of feeding places and roosts for hooded cranes at Yashiro.

Factors that influenced the loss of feeding sites include: (1) construction of villagers' houses and roads at two sites; (2) devastation of farmlands at two sites; (3) loss of roosts

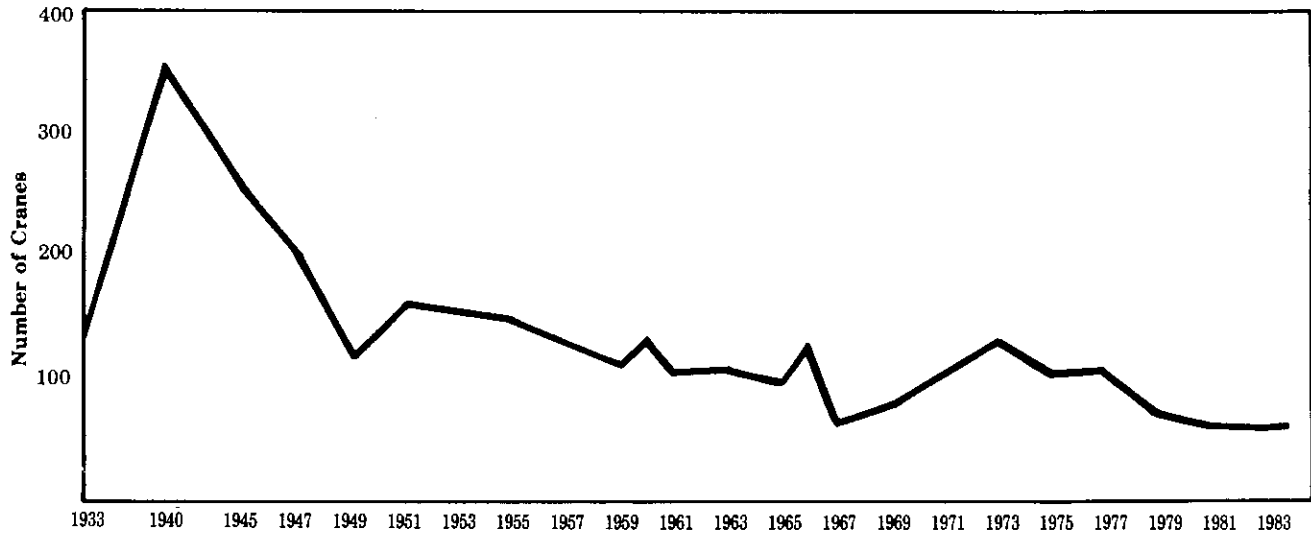


Figure 1. Population of hooded cranes at Yashiro, Japan 1933-1979.

near two feeding sites; (4) use of agricultural chemicals in feeding areas accompanied by a decrease in small fish and small mammals; (5) a decrease in wintering cranes; and (6) overcrowding into limited feeding sites, with abandonment of other sites.

According to our observations, the main causes of loss of some feeding sites were not due to deterioration of the environment but to the cranes' activities. Most feeding sites that were abandoned could be recovered if the cranes would change their activities.

#### Roosts

Roosts are on wet paddies in long narrow valleys far from human and animal habitation. Their size ranges from 3-10 a (100 a = 1 ha).

Table 1 shows that the number of roosts decreased from 20 sites in 1971 to 7 sites in 1981 (Kawamura 1975). Factors that influenced the loss of roosts include: (1) construction of a golf course in 1972 (seven places); (2) a governmental policy of reduction of rice paddy areas and mechanization of agriculture, which caused trees to be planted or weeds to grow (three places); (3) incomplete trimming of wet paddies (roosts) in summer (two places); and (4) trees growing up around the roosts (two places).

Degradation of roosts proceeds very rapidly. If roosts are not trimmed in summer, they cannot be used by cranes in the winter because trees and weeds have grown up. Presently roosts are all trimmed and flooded by the villagers and volunteers before cranes migrate to these sites. Cranes do not roost in the paddies after harvest unless the areas are trimmed.

In comparing the roosts in 1971 with those in 1981, the size and number have both decreased markedly. In proportion to the decline of the size and number of roosts, the population of cranes fell from 108 birds to 66. For the conservation of cranes, it is most urgent to maintain an appropriate number of roosts.

## MEASURES FOR CONSERVATION

### Regulations

In 1887, a prefectural regulation concerning the preservation of cranes was promulgated (see Table 2). Prior to that regulation, inhabitants in Yashiro had already started their movement to protect the cranes.

In 1904, Yashiro was designated a sanctuary, and the environment for cranes was improved, so that the crane population began to increase gradually.

In 1921, cranes were designated a natural monument, and the expense for construction of fences to protect cranes was budgeted. Bulletin boards were also put up.

In 1955, cranes were designated a special natural monument with hopes of stopping their decrease. Loach culture was begun, to provide fish as food for the cranes, but this practice was stopped in a few years. Various regulations were enacted, but as the factors causing a decrease of the population were not fully understood, proper measures for conservation could not be implemented.

### Feeding

As farmland in Yashiro is limited, it is necessary to continue to feed the cranes to keep their numbers from declining further.

In 1921, feeding costs were budgeted. Since then feeding has continued, although the size of the budget has fluctuated according to the year. In the beginning, mainly unhulled rice was provided, but there were apparently also a great many loach and other small fish in the fields and rivers. Since around 1975, wheat and corn have been fed. Currently, 1500 kg of cereals and about 200 kg of loach are fed to the birds.

Today, however, it is more important to end the use of agricultural chemicals, in order to let small animals



reproduce, than it is to increase the amount of food artificially provided. Hence it is an urgent task to purchase larger paddies. The goal should be to improve the supply of natural and artificial foods over a larger area in order to encourage dispersal of the cranes.

Winter Population		Comments and Measures for Conservation
1877	10	hooded cranes began to appear at Yashiro
1887	?	promulgation of prefectural regulations for the purpose of conservation of cranes
1902	35	increasing number of cranes
1904	?	designation as a sanctuary
1921	100	designation as a natural monument funds budgeted for feeding cranes: unhulled rice 100 kg
1922	?	cranes fed unhulled rice (140 kg) and fish
1940	355	maximum number of cranes
1955	150	designation as a special natural monument
1958	120	beginning of breeding loach for crane food reduction of loach because of agricultural chemicals and dry paddies
1963	110	construction of a crane observatory and fences to protect feeding areas beginning of regular feeding by volunteer observer
1964	109	purchase of 55 a of paddies as feeding sites purchase of mountains as roosts: 341 a
1975	108	construction of golf course and loss of roosts decline of roosts influenced by the policy of reduction of rice paddy area purchase of 70 a of fields as roosts
1976	114	another purchase of 35 a of fields for roosts
1977	104	another purchase of 27 a of feeding area
1980	61	decrease of cranes
1986	57	decrease of cranes

**Table 2.** Fluctuation of the hooded crane population and measures for conservation, 1877-1986.

### Feeding Areas

Cranes tend to flock at a single rice paddy, where grain is spread, rather than at other paddies where grain is not spread. Some 87 a of feeding sites have been purchased by Yashiro town. At the beginning of winter some early arriving families form territories in this 87 a and prevent other families from using it. This 87 a occupies less than 10% of locally available farmland. It is so modest a size that at least two more feeding areas should be purchased, making it possible to decentralize the feeding places.

At the end of winter, cranes sometimes disappear early from Yashiro. At this time the hooded cranes are so sensitive to human activities that they must be protected from any intervention by people. A similar problem occurs in November and December when it is time for the cranes to form their territories in broad areas. At that time friction between people and cranes can often be seen. Therefore some regulations are needed to cover areas outside the government-owned land.

### Roosts

The disappearance and degradation of roosts has most directly caused the decline in the number of cranes. The importance of roosts was pointed out long ago, and the purchase of roosts by the town with management by volunteers has been implemented (Kawamura 1975).

To enlarge and stabilize these accomplishments, a plan for roosts on a larger scale is needed. The area that the town has purchased so far is 341 a of mountains and 105 a of paddies, but the land is still too limited for crane requirements. Kumage town should purchase more fields for management of the cranes.

### THE IMPORTANCE OF YASHIRO

At present, almost all the world's hooded cranes come together for winter at Izumi. This overcrowding has worsened with the decline of the number of cranes at Yashiro. Because of overcrowding, the cranes at Izumi cause problems with local farmers, and the species is greatly at risk from disease and natural disaster. It is necessary to decentralize wintering places for hooded cranes as soon as possible. A primary goal must be the maintenance and growth of the winter flock at Yashiro.

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## FORAGING AND TIME BUDGET OF THE HOODED CRANES IN A WINTERING AREA AT YASHIRO, JAPAN

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### ABSTRACT

We studied foraging and time budget of the wintering hooded cranes *Grus monacha* in Yashiro, Yamaguchi Prefecture, Japan, from 1983 to 1985. Family groups with one or two juveniles established territories and spaced out over the wintering area, while other cranes aggregated in a flock in December. Foraging and head-up vigilance behavior occupied more than 70% of daytime activity. Adults in the flock spent more time feeding than those in families. Juveniles of both families and flock allocated as much time for feeding as adults of the flock. Time spent in head-up vigilance was much higher in adults of families than in other individuals. The rate of food intake was similar for members of all categories. Consequently territorial adult cranes obtained less food than non-territorial individuals. The defense of territory is costly for these adults. Juveniles benefit from the territory in which much time can be allocated for foraging, in spite of depletion of foods with progress of the season. The advantages of defending the territory in wintering hooded cranes may be to protect juveniles in their foraging ground and to secure food for them.

### INTRODUCTION

The hooded crane winters at two areas in Japan: Izumi in Kagoshima Prefecture, and Yashiro in Yamaguchi Prefecture. The number of cranes wintering in Japan has been increasing recently, so that the wintering area of the hooded cranes seems to be primarily limited to these two areas in the world (Johnsgard 1983). Some management practices for preservation are being promoted by national and municipal governments on the wintering areas. But two contrasting problems have arisen there: over-population in Izumi carries a risk of extinction from epidemic disease or catastrophic disaster; and, on the other hand, the decline in the number of wintering cranes at Yashiro causes people to anticipate the disappearance of the wintering population there. These problems suggest the necessity for encouraging the development of new wintering areas and the effective diffusion of wintering cranes. Studies on the behavior and social structure of the cranes can help promote proper management of the wintering areas.

Although a few fragmental descriptions have been reported on the behavior of the wintering hooded cranes (e.g., Kawamura 1981; Nishida 1981), to date no quantitative studies have been conducted. We carried out a study on the activity pattern and home range utilization of the hooded cranes at Yashiro from 1983 to 1986. During the study, we found that there were a few territorial cranes and many non-territorial ones, and that the birds adopting different social systems showed different activity patterns.

In this paper, we measure the time budget of individuals belonging to territorial families and to a non-territorial group, and discuss the function of the winter territory of the hooded cranes. Although the study was carried out in every month during the wintering period, the discussion

is based primarily on data collected in December when the territories were established.

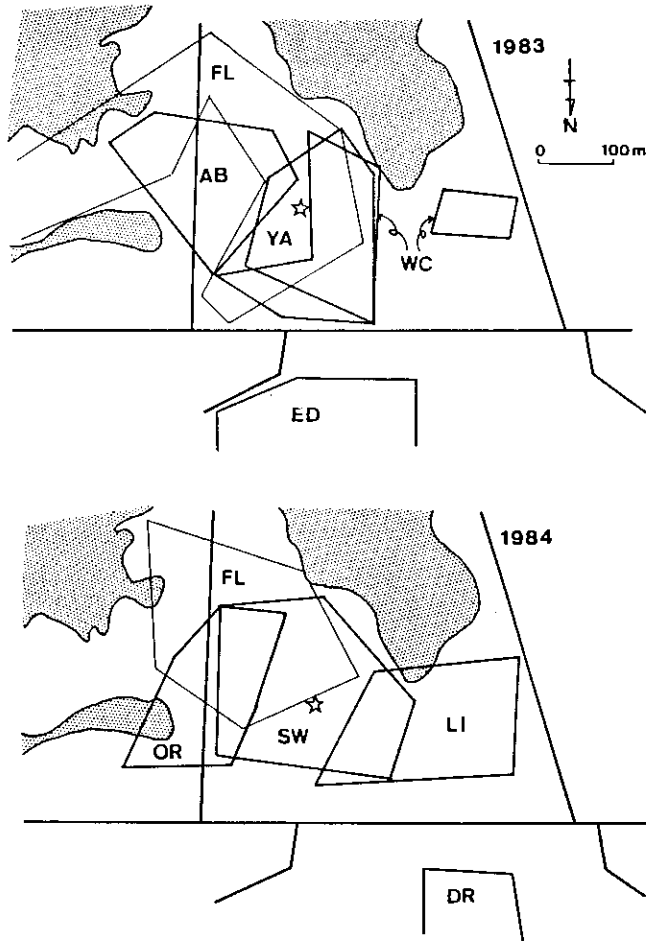
### BRIEF DESCRIPTION OF THE WINTERING POPULATION AT YASHIRO

The wintering area at Yashiro is situated on the southwestern end of Honshu (the largest of four main islands of Japan), and is a small basin, 320 m above sea level, occupied primarily by grain fields that are surrounded by some houses, roads, and hills. Cranes have been wintering here for many hundreds of years. In the past, the number of cranes reached as high as 250 individuals, but recently they have decreased. The maximum number of wintering cranes and percentage of juveniles were 62 and 14.5% in 1983-84, 62 and 25.8% in 1984-85, and 64 and 23.4% in 1985-86.

Cranes begin arriving at Yashiro in late October, increase until early January, and later migrate all together on one day in early March. At the wintering area, cranes spend daytime hours within a foraging area that includes 35 ha of grain fields around a 1 ha artificial feeding site. The cranes roost communally at wet rice paddies and along the shore of a pond 2 to 5 km away from the foraging area.

In the earlier part of the wintering period, the population mainly consists of families accompanied by one or two juveniles. These families try to establish their territories within the foraging area, but the distribution of territories is rather changeable in November. In December, several families establish territories ranging from 2.8 - 6.8 ha, while other members of the population aggregate in a flock and wander over the area including into a few territories (Figure 1). Although cranes temporarily congregate in a flock when they are disturbed by humans or vehicles, all territories are otherwise maintained throughout the day.

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**Figure 1.** The distribution of crane territories and the activity area of the non-territorial flock. Stippled areas are hills, bold straight lines are roads, polygons with bold lines are territories, polygons with thin lines are the activity area of the flock, and stars are the artificial feeding site. In 1983, WC had two territories separated from each other, and ED sometimes joined the flock.

With the increase in the number of wintering cranes, a few families join the non-territorial flock because of the difficulty in defending their territories. By January, all territories are abandoned and all members of the population aggregate in a flock. Thereafter, activity range of the flock is limited to a small area around the artificial feeding site. There are no artificial structures in the feeding site, but cereals (wheat, rice, and corn) are supplied by the Town Government during the wintering period. In November and December, one or two families establish territories on the feeding site and monopolize it, but the degree of utilization is rather low (e.g., 10 - 27% of the total locations of dominant families as recorded every 30 min). Instead cranes mainly feed on waste rice on harvested paddies. In January and February, however, cranes gather around the feeding site and mainly depend on foods artificially supplied because of the depletion of natural foods.

## METHODS

The study was carried out for five to six days every year. Four to five researchers observed cranes from three or four points from dawn to dusk. Focal animal observation was used for assessing time spent in each activity type by individual cranes. One researcher observed one to four individuals in a view continuously with a telescope (20x or 25x) for 10 minutes and recorded the times that changes in activity type took place with a tape recorder. Ten minute observations were replicated at least once per 30 min. For feeding individuals, the rate of food intake was calculated by counting the number of food items swallowed in 60 sec. We recorded the location of individual cranes on a map every 30 min.; we then calculated the intensity of utilization of the artificial feeding site as the percentage of occurrence at the feeding site against the total number of observations.

Six types of activities were distinguished: feed, search, head-up, social behaviors, preen, and move. **Feed** includes pecking on the ground, ingesting foods, and drinking water. **Search** means walking with the head lowered toward the ground. **Head-up** means the vigilance stance stimulated by predators, conspecific individuals, and other sources of disturbance. **Social behaviors** include chasing or being chased by other individuals, threat or unison call, flying immediately preceded or followed by distinct aggressive behaviors, and courtship display. **Move** includes both walking and flying unaccompanied by aggressive behaviors.

Individual identification was based on the number of juveniles belonging to each family and on the plumage pattern, particularly the pattern on the edge of the gray neck feathers. It was difficult, however, to distinguish the family members from other individuals when they joined the flock. Sexing for adults was based on the unison call (Archibald 1976), but this identification was not always possible. Therefore data were lumped for both sexes in the analysis of activities. Both identification and sexing were impossible for juveniles.

A unique notation is used for indicating the category of family in this paper. For example, a family with two juveniles is indicated as "NF4-2": "NF" means a family, the first numeral is the number of family members, and the second is the number of juveniles.

## RESULTS

In December 1983, three NF4-2s and three NF3-1s wintered at Yashiro. Of these families, three NF4-2s and one NF3-1 established territories. The non-territorial flock numbered 23 cranes. In December 1984, there were nine families (three NF4-2s, one NF3-2, and five NF3-1s); two NF4-2s and three NF3-1s established territories. Besides these families, a pair without young exhibited territorial behavior. The flock size was 13. In 1985-86, the influx of wintering cranes was unusually early, so most families abandoned their territories and only two families (one NF4-2 and one NF3-1) of four NF4-2s and five NF3-1s still maintained a territory in December. The flock size was 22.

Table 1 shows the percentage of daytime spent in each

Activity type	Family		Flock	
	Adult	Juvenile	Adult	Juvenile
Feed	40.78±2.26	57.10±1.33	53.45±3.05	63.01±4.87
Search	3.40±0.30	4.68±0.38	3.32±0.54	7.83±2.01
Head-up	33.91±1.07	25.42±0.87	19.77±1.39	16.53±2.47
Social Behaviors	1.82±0.06	0.44±0.01	0.93±0.07	0.20±0.03
Preen	12.97±1.10	7.90±0.88	12.71±1.90	6.98±2.81
Move	6.36±0.70	4.58±0.62	5.87±1.00	6.15±1.67
No. of Observations	327	196	106	29

**Table 1.** Mean ( $\pm$ SE) percentage of daytime spent in different activity types by the hooded cranes of territorial families and of a non-territorial flock in December, 1983 to 1985.

activity type by adults and juveniles belonging to the territorial families and to the flock. Because the results were similar between years, data were lumped for the three years. Feed and head-up occupied more than 70% of the daytime activity. Adults in families spent much less time feeding, 41% versus 53% ( $t=2.923$ ,  $P < 0.001$ ), and more time in head-up, 34% versus 20% ( $t=6.932$ ,  $P < 0.001$ ) than those in the flock. The former spent more time in social behaviors that were mainly aggressive ( $t=7.896$ ,  $P < 0.001$ ), but the amount of time spent was very small. Between other minor activity types, there were no significant differences among adults. Between juveniles in families and those in the flock, the only significant difference was in time spent in head-up ( $t=3.624$ ,  $P < 0.001$ ). Adults allocated more time to head-up, social behaviors, and preen, and less time to feed and search than juveniles both within family and within flock, although the differences were not significant in search and social behaviors within the flock.

Tables 2 and 3 show the time budget of territorial families. Since identification of families was infrequent in 1985, data are shown for 1983 (families YA, AB, ED, and WC) and 1984 (families SW, OR, DR, and LI). LI was a pair without a juvenile. YA and SW were dominant and established territories in the center of the foraging area (Figure 1). AB

and OR established their territories in the eastern part, ED and DR in the northern part and WC and LI in the western part of the foraging area. Each of four families in 1984 established their territory in the same place occupied by its respective predecessor in 1983. This suggests that adults of families in 1984 were identical with those families in 1983. We have no evidence on this point, however, because no cranes were tagged.

Dominant-subordinate relationships were not clear among families except for YA and SW. Adults of the dominant family spent much less time in feed than those of other families for both 1983 and 1984. They allocated more time in head-up than did subordinate adults in 1983, but not in 1984. Adults of YA, SW, AB, and OR, whose territories were situated within the area in which the flock wandered, allocated more time to social behaviors than did adults of other families. Otherwise, there were no significant differences among subordinate adults in any of the activity types except for preening in 1983. There were no significant differences among juveniles, either.

Table 4 shows the rate of food intake in December of 1983, 1984, and 1985. Because there were no significant differences between sexes and between the members of the territorial families and non-territorial flock, data were shown separately only for adults and juveniles. Between adults and

Family	Age	Number of Observations	Social Behaviors					
			Feed	Search	Head-up	Preen	Move	
YA NF4-2	Adult	32	22.22 ( 3.86)	4.22 ( 0.81)	51.48 ( 3.32)	3.05 ( 0.20)	10.53 ( 2.41)	8.56 ( 3.28)
	Juvenile	39	48.33 ( 4.01)	7.31 ( 1.03)	31.41 ( 2.34)	0.77 ( 0.06)	8.41 ( 2.72)	4.08 ( 2.32)
AB NF3-1	Adult	29	44.52 ( 3.16)	5.41 ( 0.84)	34.46 ( 1.75)	2.20 ( 0.11)	4.93 ( 1.96)	8.62 ( 2.12)
	Juvenile	17	55.82 ( 5.08)	5.88 ( 1.67)	25.41 ( 2.62)	0.18 ( 0.20)	6.24 ( 3.47)	6.59 ( 2.56)
ED NF4-2	Adult	12	48.42 ( 7.51)	3.92 ( 1.23)	40.83 ( 5.48)	0.00 ( )	6.83 ( 1.99)	0.17 ( 0.17)
	Juvenile	6	67.67 ( 6.94)	3.00 ( 1.91)	21.50 ( 2.13)	0.00 ( )	7.50 ( 4.63)	0.33 ( 0.33)
WC NF4-2	Adult	13	37.08 ( 7.15)	5.85 ( 1.74)	28.86 ( 4.01)	1.14 ( 0.16)	15.31 ( 5.63)	11.23 ( 3.30)
	Juvenile	5	40.60 ( 8.56)	7.00 ( 3.47)	22.20 ( 4.06)	0.00 ( )	28.60 ( 11.50)	2.00 ( 1.31)

**Table 2.** Mean ( $\pm$ SE) percentage of daytime spent in different activity types by the hooded cranes of territorial families in December 1983.

Family	Age	Number of Observations	Feed	Search	Head-up	Social Behaviors	Preen	Move
SW NF4-2	Adult	60	39.47 ( 2.98)	2.43 ( 0.46)	38.01 ( 2.47)	1.83 ( 0.12)	11.28 ( 2.01)	6.94 ( 1.83)
	Juvenile	30	61.70 ( 2.99)	4.43 ( 1.24)	24.68 ( 2.76)	0.47 ( 0.05)	4.00 ( 1.31)	4.71 ( 1.66)
OR NF3-1	Adult	60	52.61 ( 3.26)	2.39 ( 0.48)	30.37 ( 2.33)	2.71 ( 0.21)	6.89 ( 1.61)	4.80 ( 1.23)
	Juvenile	30	66.50 ( 3.64)	2.97 ( 1.36)	23.26 ( 2.61)	0.33 ( 0.04)	2.35 ( 0.94)	4.57 ( 1.73)
DR NF4-2	Adult	12	38.50 ( 9.01)	4.65 ( 1.70)	43.05 ( 7.15)	0.00 ( )	11.35 ( 3.34)	2.40 ( 0.77)
	Juvenile	6	44.70 (12.61)	6.80 ( 5.06)	30.60 ( 8.37)	0.00 ( )	16.60 (14.00)	1.30 ( 0.61)
LI NF2-0	Adult	15	47.48 ( 6.79)	3.18 ( 0.94)	33.36 ( 5.05)	0.24 ( 0.04)	9.29 ( 3.94)	6.16 ( 2.21)

Table 3. Mean ( $\pm$ SE) percentage of daytime spent in different activity types by the hooded cranes of territorial families in December 1984.

Year	Age	Inside Feeding Site	Number of Observations	Outside Feeding Site	Number of Observations	t value
1983	Adult	33.8	( 2)	27.4 $\pm$ 1.0	(169)	—
	Juvenile	38.1 $\pm$ 4.5	( 5)	24.7 $\pm$ 1.2	( 95)	2.530*
	t value			1.737		
1984	Adult	50.1 $\pm$ 2.9	(35)	22.3 $\pm$ 1.4	(106)	9.282***
	Juvenile	52.6 $\pm$ 2.9	(28)	23.0 $\pm$ 3.9	( 28)	6.103***
	t value	0.608		0.203		
1985	Adult	34.9 $\pm$ 2.1	(50)	21.0 $\pm$ 2.7	( 54)	3.890***
	Juvenile	27.4 $\pm$ 4.2	(17)	8.9 $\pm$ 1.9	( 21)	4.236***
	t value	1.638		2.652**		

\* =  $P < 0.05$ , \*\* =  $P < 0.01$ , \*\*\* =  $P < 0.001$

Table 4. Mean ( $\pm$ SE) number of times of food intake per 60 sec inside and outside the artificial feeding site in December.

juveniles, there were no significant differences except for data collected from outside of the artificial feeding site in 1985 which showed that juveniles obtained much less food than adults. For every year, the rate of intake was lower outside the feeding site.

Although the artificial feeding site provided plenty of food, the intensity of utilization by cranes was rather low in December. Even dominant families (YA and SW) spent only a short time in the artificial feeding site: 10-27% of the total locations for these birds. No other families stayed here. Only a few of the flock members invaded and briefly foraged here (2.3% and 0%, respectively, of the total number of observed crane locations in 1983 and 1984).

Calculated from the individual values of the rate of utilization of the artificial feeding site and the rates of food intake inside and outside the artificial feeding site, the average rate of food intake per minute (RIM) for each family and flock was obtained (Table 5). Data were lumped for adults and juveniles. The rate was low for the families occupying the western part of the foraging area (WC in 1983 and LI in 1984), and, in contrast, was remarkably high in DR. The corresponding values in dominant families were around the mean.

About ten hours were spent in the foraging area in

December (the entire daytime period). Multiplying RIM by the percentage of time spent in feed and by the length of daytime, the rate of food intake per day (RID) was obtained (Table 5). Based on the assumption that a crane swallowed one grain of cereal at a time, 3,000-5,460 grains were eaten by adults of YA and SW, 6,480-8,400

Crane Group	RIM	RID	
	(grains of cereal/minute)	(1,000 grains of cereal/day) Adult	Juvenile
1983			
YA	22.4	3.00	6.48
AB	28.1	7.50	9.42
ED	28.9	8.40	11.76
WC	16.9	3.78	4.08
Flock	32.1	11.94	9.84
1984			
SW	22.7	5.46	8.40
OR	21.3	6.66	8.52
DR	48.4	11.16	12.96
LI	11.1	3.18	—
Flock	26.4	9.00	12.30

Table 5. The rate of food intake per minute (RIM) and per day (RID) for families and for the flock, 1983 and 1984.

grains by their respective juveniles, and 9,000-12,300 grains by flock members. The rate was comparatively low in adults of dominant families (YA and SW) and all members of WC and LI. Dominant adults spent more time in head-up for vigilance and less time in foraging, which may have caused the daily rate of food intake to be low. In the case of WC and LI, the low quality of the territory may be the cause. Juveniles attained almost the same rate as the flock members, although there were some exceptions.

#### DISCUSSION

Possessing the territory was costly for the adults in families. There are two sources of the cost. The first cost is aggressive behavior for defending the territory itself. YA and SW established their territories in a place where human disturbance was sporadic and, probably, the foods were rich; but they suffered frequent invasions and tried to chase out invaders. Defending requires great energy, but the overall time spent was small (Tables 2 and 3). The second cost is the increase of time for vigilance per individual with the decrease of group size (cf. Krebs and Davies 1981). The more time spent in vigilance, the less time is allocated to foraging and maintenance. Such a cost may be serious for a species whose total activity time is limited or which needs much foraging time.

Indeed, territorial cranes allocated more time to vigilance than did the flock members. Vigilance was against the invasions by conspecific individuals, predators, and other sources of disturbance. We cannot clearly differentiate our results according to these causes. Conspecific individuals, however, may have necessitated the greatest part of vigilance for YA, SW, AB, and OR. On the other hand, other sources of disturbance may have aroused adults of ED and DR, whose territories were situated at the place where disturbance by humans and vehicles was frequent. Cost was imposed primarily on adults. Within the territory, juveniles could gain much food, thus promoting body growth. In red-crowned cranes *Grus japonensis*, some families defend a territory during the non-breeding season, in order to secure foods for juveniles, but juveniles do not participate in defending (Masatomi 1974). In our study, juvenile hooded cranes in territorial families were not always released from the vigilance duties, although they seldom participated in territorial defense. Hence, juveniles in territorial families could not obtain as much food as those juveniles in families that abandoned their territories and joined the flock.

Our data showed that neither adults nor juveniles in the

dominant families were able to compensate for the decrease in time spent foraging by a greater rate of food intake from the rich food resources of their territories in December. Nevertheless, territories were distinctly defended by the families. We will present a possible explanation for the function of a winter territory for the hooded crane. The main food supply of the hooded crane, other than artificially supplied cereals, is not renewable. Hence, it is advantageous for a hooded crane family to occupy an area large enough to supply food throughout the wintering period. Because the decrease of natural food (such as waste rice) was not so serious in December, the intensity of utilization of the artificial feeding site was low. The advantages of defending territories may have been masked by the advantages promoted by living in a large group. Flock members, spending less time in vigilance behavior, had more time for feeding.

Mean territory size was around 5 ha. The foraging area (35 ha) may have been too small for the present population. The depletion rate of natural food was so fast that the rate of food intake decreased in January to 20 - 50% of the November rate of food intake outside the artificial feeding site. The depletion of natural food, the small territories, and the uneven distribution of food caused by the artificial feeding site apparently facilitated the abandonment of territories. But in a more natural situation with larger territories, the advantages of territoriality would become apparent in this late winter period; the territories would insure adequate food for the crane families as food supplies dwindled.

In other words, the present population is maintained by an artificial food supply. If the foraging area were larger than the present one and no food was supplied artificially, territorial defense would facilitate the dispersal of families over the area and lower the rate of food depletion. This theory is supported by the fact that the territory of DR was seldom invaded by other families or members of the flock, perhaps due to frequent disturbance by humans and vehicles. As a result, the members of DR retained a high rate of food intake (Table 5).

Moreover, it is said that individual families dispersed over a much larger area in Yashiro in the years before the regular supplying of food began. Further studies are necessary to determine practices that could result in a population living over a larger area with less dependence on artificial food supplies. We do, however, show a tentative conclusion here. The winter territory of the hooded crane families functions to secure foods for the juveniles during the wintering period.

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# RETURNS AND RECOVERIES OF HOODED AND WHITE-NAPED CRANES BANDED IN WINTER AT IZUMI, JAPAN

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## ABSTRACT

From 1979 to 1987, 92 hooded cranes *Grus monacha*, 29 white-naped cranes *G. vipio*, and 1 common crane *G. grus* were captured and marked with metal bands and numbered color bands at the Izumi wintering area in Japan. Return dates for the year after banding were 70% for hooded cranes, and 78% for white-naped cranes. Those rates, which are related to survival rates, are higher for adults (78%) than juveniles (60%) in hooded cranes. For hooded and white-naped cranes, we obtained recovery and resighting records from the U.S.S.R. (both species), South Korea (both species), North Korea (hooded only) and China (white-naped only).

## INTRODUCTION

There are several reports on the study of migration behavior in which color banding of sandhill cranes *Grus canadensis* was used (Huey 1965; Boise 1978). But such research has not been done on hooded and white-naped cranes.

The study was conducted at the largest wintering ground of cranes in Japan, at Izumi City, Kagoshima Prefecture, Kyushu Island (32° 07' N, 130° 16' E). In the winter of 1986-87, about 6,800 hooded and 1,200 white-naped cranes were counted there.

## MATERIALS AND METHODS

Cranes were captured by rocket nets obtained from the Wildlife Materials Incorporated (17×13 m, 500 mm square mesh). To avoid escapes from the net, skirts (1 m width, 155 mm square mesh) were attached around the net. These skirts worked well. The captures were made on rice paddies, called "west reclaimed land" (about 30 ha), beside the roosting and feeding areas of the cranes. After several days' observation, some wheat was scattered at the main feeding site in the territory of a family group. If the crane family began to eat the wheat, the rocket net was set at that place during the night when the cranes were not there. Usually one or two families of different species were caught at each firing of the net. The relationships between individuals were obvious. A clap net (10×3 m) was also tested, but the net's small size made it ineffective for catching the cranes.

Cranes were banded with a metal band provided by the Japanese Environment Agency and by a numbered color leg band (7 cm height, Lynnpoly plastic). A small plastic band (2.5 cm height) was also attached around the metal band to indicate the year of birth. In addition, we banded birds that were injured or entangled in crop protection nets; these had been nursed back to health and were judged able to lead a normal life. After we banded the cranes, they were measured and weighed.

On their breeding grounds in the U.S.S.R., both hooded and white-naped cranes were caught by Soviet scientists Y. Shibaev of the Far East Science Center, S. Smirenskii of Moscow State University, and V. Andronov of Chingansky Reserve. Color bands sent from Japan were used.

Observations in Japan were made using binoculars or 20× to 60× spotting telescopes. The main roosting and feeding site was checked repeatedly. The location of banded birds, their behavior, and their relationships with other cranes were recorded. Resighting data from other observers were also collected when possible (Abe et al. 1987).

## RESULTS AND DISCUSSION

### Banding

In total, 122 cranes of three species were banded over eight winters (Table 1). For hooded cranes, 55 birds were caught by rocket nets, 37 were injured or entangled in crop protection nets, and only 2 were caught by a clap net. White-naped and common cranes were caught by rocket nets. All 22 rocket net attempts were successful. The mean number of cranes captured per firing of the rocket was about four individuals. No cranes were killed or injured during the rocket netting.

Season	<i>Grus monacha</i>			<i>G. vipio</i>			<i>G. grus</i>
	Adult	Juv.	Total	Adult	Juv.	Total	Adult
1979-80	1	2	3	-	-	-	-
1980-81	2	1	3	-	-	-	-
1981-82	1	1	2	-	-	-	-
1982-83	6	1	7	7	2	9	-
1983-84	6	2	8	6	5	11	-
1984-85	11	9	20	2	3	5	-
1985-86	9	9	18	2	-	2	-
1986-87	16	15	31	2	-	2	1
Total	52	40	92	19	10	29	1

Table 1. Numbers of cranes banded at Izumi.

## RETURNS

Return rates the next winter after banding were 70% in hooded and 78% in white-naped cranes (Tables 2 and 3). In hooded cranes, the return rates were higher in adults (78%) than in juveniles (60%). In white-naped cranes, adults also had a higher return rate (82%) than did juveniles (70%). The sample sizes are still too small for statistical analysis.

Years After Banded	Adults %	Juveniles %	Total %
1	78 (28) <sup>a</sup>	60 (15) <sup>a</sup>	70
2	63 (17)	50 (8)	58
3	44 (7)	43 (3)	43
4	40 (4)	20 (1)	33
5	25 (1)	25 (1)	25
6	0 (0)	33 (1)	17
7	0 (0)	50 (1)	33

**Table 2.** Return rates of *Grus monacha*.  
<sup>a</sup>( ) sample size.

Years After Banded	Adults %	Juveniles %	Totals %
1	82 (14) <sup>a</sup>	70 (7) <sup>a</sup>	78
2	60 (9)	50 (5)	56
3	50 (6)	57 (4)	52
4	16 (1)	0 (0)	13

**Table 3.** Return rates of *Grus vipio*.  
<sup>a</sup>( ) sample size.

The return rates are indicative of survival rates, on the assumption that all surviving birds come back to the same wintering ground each winter and that observations are adequate to check all banded birds. A few birds were not seen one winter but were then observed the next winter. In these cases, the bird was added to the survival rate for the former winter.

One banded hooded crane was reported from South Korea in late November 1986, but we could not find the bird at Izumi that winter. Either the bird had died, or possibly some hooded cranes winter in Japan one year and elsewhere another year.

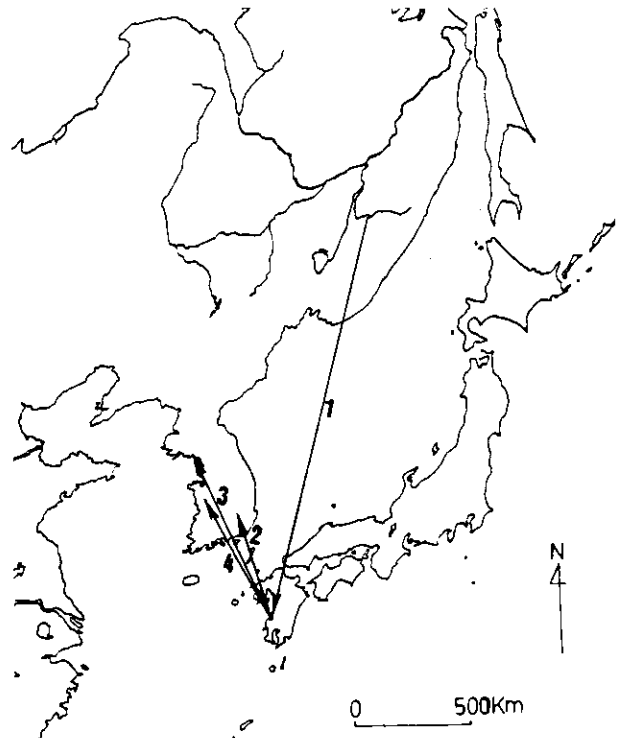
One hooded crane was found dead in Izumi during the winter it was banded.

## RECOVERIES

Of hooded cranes banded in Japan, two recoveries (birds found dead) and one resighting record were reported from North and South Korea (Figure 1 and Table 4). All four hooded cranes banded in the U.S.S.R. were observed at Izumi. These data suggests that hooded cranes migrate through the Korean peninsula en route between the U.S.S.R. and Japan.

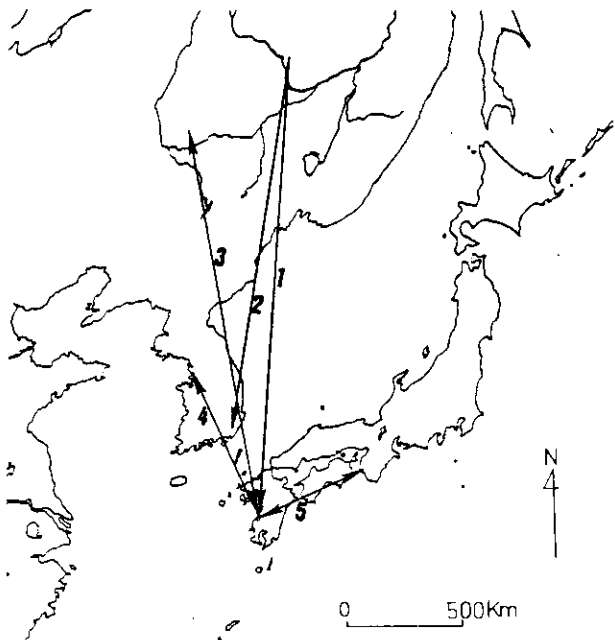
Of white-naped cranes banded in Japan, two recoveries (found dead) and four resightings in South Korea, and one resighting in China, have been reported (Figure 2 and Table 5). Five white-naped cranes banded in Chingansky and Amursky Reserves of the U.S.S.R. were also observed at Izumi. But we could not find six other white-naped

banded in Chingansky Reserve between 1984 and 1986. It is interesting that of the birds from the same breeding population, some migrate to Izumi while the rest migrate to different wintering grounds outside Japan.



**Figure 1.** Recoveries of hooded cranes.

Note: Data for each arrow are described in Table 4. The arrows indicate only the banding and recovery (or resighting) locations, not the migration routes.



**Figure 2.** Recoveries of white-naped cranes.

Note: Data for each arrow are described in Table 5.

No. on Fig. 1	Color Band		Banded				Recovered or Resighted	
	No.	Color	Sex	Age	Date	Location	Date	Location
1	A50	White	U <sup>a</sup>	Adult	20.7.1985	Verkni Pereval Village, U.S.S.R.	21.10.1985-17.1.1986 18.11.1986-19.1.1987	Izumi, Japan same as above
1	A51	White	U	Adult	22.7.1985	Alcan River, U.S.S.R.	2.11.1985-17.1.1986 18.11.1986-16.1.1987	same as above same as above
1	A52	White	U	Juvenile	22.7.1985	Verkni Pereval Village, U.S.S.R.	10.11.1985-17.1.1986	same as above
1	A53	White	U	Adult	24.7.1985	Bikin Alcan Bog, U.S.S.R.	10.11.1985-17.1.1986 18.11.1986-8.1.1987	same as above same as above
2	J25	Yellow	U	Juvenile	11.12.1984 <sup>b</sup>	Izumi, Japan	29.11.1986	Tasan, Koryong-gun, South Korea
3	J03	Yellow	U	Adult	25.2.1983 <sup>c</sup>	same as above	(30.3.1984)	Pekchun-gun, North Korea
4	5	Orange	♂	Adult	3.12.1980 <sup>d</sup>	same as above	(22.3.1985)	Imchon-myon, Puyo- gun, South Korea

Table 4. Banding and recovery data of hooded cranes (see Figure 1).

<sup>a</sup> U: Unknown      <sup>b</sup> resighting records at the banding site on 16.1.1985-23.3.1985 and 22.10.1985-14.1.1986      <sup>c</sup> 1.1.1984-13.2.1984  
<sup>d</sup> 18.12.1980, 25.10.1981-18.12.1981, 19.12.1982-12.2.1983, 30.10.1983-21.1.1984 and 15.1.1985      ( ) :found dead

No. on Fig. 2	Color Band		Banded				Recovered or Resighted	
	No.	Color	Sex	Age	Date	Location	Date	Location
1	057 <sup>b</sup>	Yellow	U <sup>a</sup>	Pullet	22.7.1984	Chingansky Reserve, U.S.S.R.	8.12.1984-23.3.1985	Izumi, Japan
1	060 <sup>c</sup>	Yellow	U	Pullet	22.7.1984	same as above	8.12.1984-3.3.1985 22.10.1985-14.1.1986 20.11.1986-21.11.1986	same as above same as above same as above
1	A18	White	U	Adult	14.7.1985	same as above	21.10.1985-23.1.1986 19.11.1986-16.1.1987	same as above same as above
1	A19	White	U	Adult	14.7.1985	same as above	10.12.1985-13.1.1986 19.11.1986-16.1.1987	same as above same as above
1	A42	White	U	Adult	30.7.1986	confluence of Zeia and Amur River, U.S.S.R.	18.11.1986-13.1.1987	same as above
2	A26	White	U	Pullet	4.8.1985	Chingansky Reserve, U.S.S.R.	(9.2.1986)	Daedong-myon, Kim hae-gun, South Korea
3	J17 <sup>d</sup>	Yellow	♂	Adult	25.1.1984 <sup>f</sup>	Izumi, Japan	21.4.1986-? 10.1986 <sup>g</sup> 29.3.1987-18.6.1987	Zhalong Reserve, China same as above
4	J18 <sup>e</sup>	Yellow	♀	Adult	25.1.1984 <sup>h</sup>	same as above	(11.3.1985)	Gyoha-myon, Paju- gun, South Korea
4	17	Orange	U	Adult	13.1.1983	same as above	(7.12.1983)	Daegot-myon, Kim-po- gun, South Korea
4	?	Orange	U	U	12-13.1.1983	same as above	4.3.1983	Gunnae-myon, Paju- gun, South Korea
4	? <sup>i</sup>	Yellow	U	U	18-25.1.1984	same as above	10.3.1984	Hasong-myon, Kim- po-gun, South Korea
5	J16	Yellow	U	Juvenile	24.1.1984 <sup>j</sup>	same as above	15.3.1986-21.3.1986	Mihama-cho, Hida- ka-gun, Wakayama- Prefecture, Japan

Table 5. Banding and recovery data of white-naped cranes (see Figure 2).

<sup>a</sup> U: Unknown      <sup>b</sup> and <sup>c</sup> are in same brood      <sup>d</sup> and <sup>e</sup> are pair  
<sup>f</sup> resighting records at the banding site on 27.1.1985, 25.12.1985 and 7.1.1987-19.1.1987  
<sup>g</sup> on 23.3.1984-October 1984 in Zhalong, yellow color banded pair (No. unknown) were observed.  
<sup>h</sup> observed on 27.1.1985 with J17 at Izumi      <sup>i</sup> three individuals  
<sup>j</sup> resighting records at the banding site on 5.11.1984-25.1.1985, 21.11.1985-31.12.1985 and 19.11.1986-16.1.1987      ( ) :found dead

One banded white-naped crane in its third winter was observed in Wakayama Prefecture (500 km northeast of Izumi) on 15-21 March 1986. Though this direction was far off the main spring migration route, the bird returned to Izumi again the next winter.

Color banding of cranes is an effective method for studying crane behavior because of the high resighting rate at both the banding site and other places. Banding on the breeding ground is the most effective way to study the relation between breeding and wintering areas.

#### ACKNOWLEDGMENTS

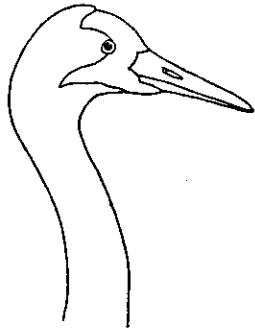
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CHAPTER 10  
SOUTHERN ASIA





## EASTERN SARUS CRANES IN INDOCHINA

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### ABSTRACT

A small flock of eastern sarus cranes *Grus antigone sharpii* winter during the dry season at Dong Thap Muoi in the lowland of the Mekong Delta. No nesting habitat remains here because of war-time activity and agricultural development. The cranes apparently move to a nearby portion of Kampuchea for breeding. An expedition to Bem Cho District in Pray Veng Province in Kampuchea found no suitable breeding habitat. In January 1987, about 100 eastern sarus cranes, including young birds, were found at Dong Thap Muoi. A 6,000-ha reserve is being established for the cranes.

Southeast Asia is home for the eastern sarus crane. But the cranes are disappearing from the greater part of their range. Hunting and especially loss of habitat are the main reasons for their decline.

In the past 30 to 40 years sarus cranes were breeding in Dong Thap Muoi, the lowland of the Mekong Delta. At that time the local people used to catch the sarus crane young and hand-rear them at home.

In the war, Dong Thap Muoi was a main target of American bombardment and toxic chemical spraying. Sarus crane habitat suffered serious damage. From 1968-1975, soldiers still used three to four helicopters to hunt the cranes in the dry season to eat and to sell in Saigon. After the liberation of the South in 1975, Dong Thap Muoi was drained to obtain land for agriculture, so that there was no place for the cranes.

Since then the cranes return in small flocks only in the dry season from November to February, to feed. In February 1985, one hunter of Tam Nong District killed two cranes with a military rifle. When we went to Dong Thap Muoi, the feathers of the victims remained.

Some old Vietnamese, who have long lived in the Bem Cho District of the Pray Veng Province on the Kampuchea side of the Kampuchean-Vietnamese border, have reported that the sarus crane was breeding there. The natural conditions are similar to those at Dong Thap Muoi, not far to the south. The local people used to hunt the birds with dogs during the molt time. It is perhaps from this area that the cranes come back to Dong Thap Muoi yearly.

One immature bird, now in Ho Chi Minh City Zoo, may also be from the Kampuchean-Vietnamese border. The young crane, apparently on its way to Dong Thap Muoi, was found in a weakened condition and not strong enough to reach its destination. The people of Phu Tan District, An Giang Province, caught and brought the bird to the City Zoo in January 1985.

Vietnam and Kampuchea now share a valuable natural resource. Therefore, in January 1986, a conservation cooperative plan between Vietnam and Kampuchea was signed in Phnom Penh under the auspices of World Wildlife

Fund representative Dr. J. MacKinnon. According to this plan, we shall investigate the status of the crane in Bem Cho District in Pray Veng Province, and also in Dong Thap Muoi in the dry season. After that we will discuss the possibilities of establishing protected sanctuaries on the border between Vietnam and Kampuchea or in Dong Thap Muoi only.

In December 1986, a long trip for field work was undertaken by our working group to Kampuchea in order to investigate in Bem Cho District as planned. Unfortunately when we got there the landscape had been changed completely. Rice paddies and irrigation dams had been built to produce food for local people, and thus there were no places for the cranes any more. The cranes had not been seen by local people for a long time. At present we believe the only breeding ground of eastern sarus cranes is the Great Lake (Tonlé Sap) area. We wanted to go there but were not allowed to because of security. Therefore the location of the sarus breeding ground is still a mystery.

After returning from Kampuchea on 5 January 1987, we went to Tam Nong District in Dong Thap Province (Dong Thap Muoi), where we had done field work last year. When we went on the canal by boat, we discovered 34 sarus cranes with our binoculars. The cranes were feeding on the "islands" of wet grassland (*Cyperus* sp.) of Tam Nong District. We watched as they picked the young leaves and sometimes dug the sedge roots for food. In the other places we observed more flocks foraging or flying. We estimated the total number of cranes at about 100 individuals. The cranes were feeding in family flocks sometimes. When we saw the cranes in small groups of about four to five individuals, there were some young (red-brown head and neck) among them.

After the discovery of eastern sarus cranes we had discussions with district authorities about establishing the crane reserve. Our idea was accepted easily, and a 6,000-ha sanctuary for the crane is being built in Tram Chim where the *Melaleuca* trees used to grow and many winter birds formerly lived.

#### ACKNOWLEDGMENTS

The management of sarus cranes requires a lot of time, money and expertise. But the Wolf Brehm Fund for International Bird Conservation has supported us effectively and on time. Thanks to this fund, we could carry out field work in the Mekong Delta and in Kampuchea, and have necessary equipment for research and planning protection for the most important bird colony in the Mekong Delta. We would like to take this opportunity to express our thanks to Wolf Brehm, Director of the biggest and most beautiful Vogelpark in the world, and to Charles Luthin, Conservation Director of the Vogelpark, who organized and arranged the Brehm Fund's assistance to Vietnam.

On this occasion we also would like to thank ICF, especially George Archibald and Jim Harris for their timely attention to conservation efforts in Vietnam. We face difficulties in expertise and finance. We hope to receive more assistance in the near future from the above-mentioned organizations and from other private institutions all over the world to fulfill our conservation tasks.



## HABITAT CONSIDERATIONS FOR BLACK-NECKED CRANES IN LADAKH

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### ABSTRACT

Three to five pairs of black-necked cranes *Grus nigricollis* arrive in Ladakh, India every spring to nest. They nest in freshwater pools and on tiny islands in lakes and rivers. They forage in shallow water, in freshwater and saline marshes, and in wet meadows surrounding the nesting area. Since 1976 investigators have made several recommendations to protect the crane pairs and their breeding habitat and feeding areas. These recommendations have focused on the dangers that threaten cranes on their breeding grounds and have initiated the process of affording protection for the breeding pairs. These recommendations, however, are not based on the study of the way different bird species utilize different habitats within these wetlands. The time has now come to undertake an in-depth study of the habits and behavior of different birds occurring on these wetlands, and to base specific management measures on results of such a study. This paper makes a beginning in this direction.

### INTRODUCTION

What is the future of black-necked cranes in Ladakh? Will this small breeding population, occupying the western-most fringe of the species' range, be able to survive and maintain its numbers? Are our efforts to augment its numbers likely to succeed? It is not possible to answer these questions without analyzing the conditions the crane pairs face on their breeding grounds, i.e. the nature of the habitats the pairs utilize for nesting and rearing their chicks. An in-depth look at the habitat patterns available to them may tell us what needs to be done to help the cranes. These measures, if translated into practice, are likely to lead to greater breeding success.

### EARLIER INVESTIGATIONS

Efforts to study and analyze the habitat conditions on the crane breeding grounds are not wanting. When the crane pairs were rediscovered in Ladakh in 1976, the importance of maintaining and protecting the wetlands that they occupied became apparent at once. The large flocks of domestic animals — sheep, goats, horses, and yaks — that grazed and wandered over these wetlands caused concern. Strict protection of the cranes from both hunters and domestic animals was recommended (Ali 1976).

The first concrete evidence of cranes breeding in Ladakh came in 1978 when a wetland was discovered that held the only black-necked crane nest known in Ladakh. Arrangements were made to protect it (Gole 1978). Another possible nesting ground was discovered later in the year (Khacher 1981), and in 1980 came the discovery of a second nest in Ladakh (Gole 1980). The result of all these field investigations was that a string of freshwater wetlands came under observation, with recommendations

made for helping crane pairs succeed in their nesting and rearing activities (Gole 1981; Khacher 1981; Hussain 1985).

### The Breeding Marshes of Chushul

It is well known that black-necked cranes breed on tundra-like marshes and bogs around the margins of, and on islands in, lakes in the Tibetan Steppes (Osmaston 1925; Ludlow 1928; Schafer 1938; Ali 1947). In 1976 when the first Bombay Natural History Society (BNHS) — World Wildlife Fund — India expedition went to Ladakh, the researchers were shown a pair of eggs that an egg-collector had pilfered from a nest in a marsh near Chushul village. Later on the expedition examined this marsh (Ali 1976). The site was a shallow depression in a plain surrounded by tall hills. An inlet stream filled the depression to form a shallow, freshwater lake. There were tiny islands in the lake, and the lake margins had floating knolls of grass.

This marsh was about 2 km from the village and was a favorite grazing ground for domestic sheep, goats, horses, and yaks. Villagers occasionally fished the lake and the stream, and a path ran along the south side of the lake. Farther away from the lake marshy land was replaced by drier grasslands, and Tibetan furze *Caragana pygmaea* bushes, rocky outcrops, and boulder-strewn screes. Wild asses *Equus hemionus*, Tibetan partridges *Perdix hodgsoniae*, and Tibetan hares *Lepus otostolus* inhabited regions farther removed from the marsh.

The investigators were told that the eggs had been collected from a nest on one of the islands in the lake. In later years, however, it was found that the cranes had abandoned this marsh for nesting, though pairs or individuals were still observed foraging in it. The increased activities of people and livestock had probably compelled the cranes to abandon the area for nesting.

The first black-necked crane nest discovered in Ladakh was found in a freshwater pool to the east of Chushul village (Gole 1978). The pool and the surrounding marsh lie at a distance of about 7 km from Chushul in a vast sandy plain with tall dunes and belts of Tibetan furze. The dunes hide the pool from the village side. The shallow pool is formed by a stream coming down the mountains to the northeast. Surrounding the basin, bogs and wet meadows stretch for some distance, giving place to dry, saline ground with encrusted salt and thorny Tihetan furze and *Myricaria elegans* bushes. A few shepherd families live in spring and summer in the sandy plain and graze their animals in the marsh. Sometimes yaks and horses wade into the pool to browse on aquatic plants such as pond weed *Potamogeton pectinatus*, milfoil *Myriophyllum* sp. The cranes used the same plants to build their nest platform in the pool.

In early July when Lavkumar Khacher visited the marsh, he found that the water level of the pool had risen considerably and the nest platform was submerged. The cranes had left the marsh and moved south, but no chicks accompanied them. Lavkumar concluded that the chicks had probably succumbed to predation, perhaps the common raven *Corvus corax* (Khacher 1981).

In 1983, when I visited this site on 31 May, I was astonished to find the ground still frozen. There was no pool, but only wet mud and the cranes had laid their eggs at approximately the same place they would have built their nest platform had there been a pool of water. The nest obviously lacked any protection and one could easily walk over the mud to examine the eggs. In 1983 the chicks again succumbed to predators and the cranes did not nest again.

The water level of the pool appears to be crucial to the nesting success of cranes.

#### The Breeding Grounds Near Hanlé

In July 1976, a black-necked pair with a chick were seen in the vast plain near Hanlé village beneath the famous Hanlé monastery (Ali 1976). Two streams meander over this plain, bringing down the snow-melt from the surrounding mountains. The pools, puddles, bogs and flowing water of this plain, give rise to the biggest freshwater marsh in Ladakh. Although in 1976 the cranes nested somewhere in this marsh, they were never observed nesting in later years. Disturbance from shepherds and the movement of villagers and security personnel over the plain probably made the cranes leave their breeding ground. Cranes did, however, use the marsh for foraging. Smaller birds such as eastern callandra larks *Melanocorypha bimaculata*, yellow-headed wagtails *Motacilla citreola*, black redstarts *Phoenicurus ochruros*, and short-toed larks *Calandrella cinerea* nested here, and the surrounding cliffs were the breeding ground of ruddy shelduck *Tadorna ferruginea*, long-legged buzzard *Buteo rufinus*, eagle owl *Bubo bubo*, and red-billed choughs *Pyrrhonorax pyrrhonorax*. In August 1986, the BNHS investigators found this marsh mostly dry with the streams reduced to small trickles and alkaline puddles (Narayan et al. 1986). Cranes, however, still used what remained of the marsh for foraging.

If alternate periods of drought and plenty are a feature of the climate in Ladakh, any analysis of wetland habitats cannot ignore this pattern.

The second nest of the black-necked crane in Ladakh was found in 1980 on a tiny islet in the swift-flowing Hanlé river, about 10 km from the Hanlé monastery (Gole 1980). The nest was not far from a desert track regularly used by villagers and security vehicles. The only protection afforded the nest was the shallow but swift-flowing river. Large flocks of domestic animals grazed in meadows along the river, although they were never seen to wade into the water. The cranes apparently did not feel any disturbance from passing vehicles, humans, and livestock. Although one time an egg-collector succeeded in pilfering the nest, this pair had the highest nesting success in Ladakh and normally reared their chicks to maturity (Gole 1980).

#### The Breeding Ground South of Tso Moriri

In 1978, Lavkumar Khacher saw a crane pair with chick in a remote corner of Ladakh, south of the lake "Tso Moriri" (Khacher 1981). I visited this area in 1980 and found it utterly desolate without any semblance of a marsh. The crane pair was there, but they had not nested by the middle of May. The only place that appeared suitable for nesting, was an island in a far corner of the lake. The island was occupied by over 100 pairs of nesting bar-headed geese *Anser indicus*. The setting was a vast, barren moonscape, devoid of vegetation and dotted with soda-encrusted alkaline pools. A tiny stream flowed into the lake from the south and some grass had begun to grow alongside. A shepherd tended his flock, even in this remote area, though the pasture could hardly justify his presence. It was apparent that the crane pair was not subjected to any interference either by humans or their domestic animals. The nesting and rearing success of this pair has as yet not been documented.

A consideration of the prevailing nesting conditions for black-necked cranes in Ladakh shows that pairs near Chushul and Hanlé are subject to a variety of disturbances. To insure their nesting success, conditions on these wetlands need to be protected.

#### PREVIOUS MANAGEMENT SUGGESTIONS

Investigators have suggested certain protective measures after studying the habitat conditions of these wetlands. Protection of cranes from gun-toting security and other personnel, as well as overall protection of the breeding areas by creating wildlife reserves, are the obvious first priorities (Ali 1976). Between 1976 and 1978 a large increase in the movements of people and livestock around these wetlands was noted, and some control over these increases was advocated. But it was also observed that the domestic animals afforded cranes a certain camouflage and hence protection, and their complete elimination from the vicinity was not desirable (Gole 1980).

Lavkumar Khacher recommended the construction of rubble walls to enclose meadows surrounding the lakes, for the prevention of damage by domestic flocks. He also

observed that "All the lakes and marshes of the Tibetan plateau are still in the process of rapidly drying up... Apart from drying up, all the Tibetan wetlands are also gradually becoming unfit for their present avifauna because of gradual filling in by aquatic plants, raising the marsh floor, and by sedges and other vegetation along the edges gradually advancing into the open water" (Khacher 1981). He further emphasized the grave threat posed to the nesting pairs by the domestic animals.

S.A. Hussain (1985), while again stressing the danger posed by livestock, also warned of the recent trend of altering the water-flow systems that feed the marshes in order to reclaim land for housing, agriculture, and pasture. He recommended prohibition of all activities within a 1 km perimeter of the nest, and monitoring and regulation of water-flow systems to avoid flooding as well as drought.

These recommendations are based on a study of the geography of these wetlands and the general habitat characteristics. These suggestions do not give adequate consideration to the uses by birds of the different local habitats. A look at habitat patterns from the standpoint of their utilization by various bird species should tell us how effective the proposed measures will be for different birds.

#### BIRD USE OF LADAKH WETLANDS

Let us first look at the bird species that are commonly found in these wetlands. I have observed birds on these wetlands in 1976, 1978, 1980, and 1983. My field notes record 28 bird species that consistently use the different

habitats available during spring and summer. The 28 common species, along with the black-necked crane, are given in Table 1. Birds are grouped according to the two most important uses they make of available habitats. These two essential activities are feeding and reproduction. Normally a bird frequents a combination of habitats to carry out these activities. Table 1 lists 10 such habitat combinations and birds are grouped according to the combination they utilize for feeding and reproduction.

The table brings out the peculiar nature of wetlands in Ladakh. As observed by earlier investigators, they are gradually shrinking in extent. Being the only freshwater sources in an otherwise cold desert region, they are used not only by wild birds and animals, but also by people, and domestic animals. The disturbance has forced some aquatic species like ruddy shelduck and goosander *Mergus merganser*, and to a lesser extent bar-headed goose to resort to cliffs for nesting. Many smaller birds like black redstart, desert wheatear *Oenanthe deserti* and Blanford's snowfinch *Montifringilla blanfordi* take advantage of low cliffs and artificial stone and rubble walls for nesting. Thus 14 out of 28 species are not directly dependent on wetlands for nesting. Ten of the 14 – those species from Habitat Combinations (HC) 4 and 7 – are not directly wetland dependent even for feeding. Any measure that affects the wetland probably will not directly affect the species.

There are 12 species – those from HC 1, 2, 5, 6 and 10 – that are wetland dependent for feeding as well as reproduction. In addition, there are two species from HC 3 that depend on wetlands only for feeding. Any measure that alters wetlands also directly impacts these 14 species.

Habitat Combination No.	Habitat Combination used by birds for reproduction and feeding	Names of birds using the combination
1	Breeds on islets. Feeds in water.	great crested grebe, brown-headed gull, common tern
2	Breeds on islets. Feeds in water, marsh, and meadows.	bar-headed goose, black-necked crane
3	Breeds in cliffs. Feeds in water.	ruddy shelduck, goosander
4	Breeds in cliffs. Feeds in meadows, among boulders, and around villages and camps.	long-legged buzzard, bearded vulture, Tibetan sandgrouse, eagle owl, common raven
5	Breeds in grass thickets. Feeds in fresh or saline marsh.	common redshank, Mongolian plover, pied wagtail, yellow-headed wagtail, short-toed lark
6	Breeds in grass thickets. Feeds in meadows and shrubs.	eastern callandra lark
7	Breeds in low cliffs, stone and mud walls. Feeds in stubble, meadows, and among rocks.	Turkestan hill pigeon, black redstart, desert wheatear, red-billed chough, Blandford's snowfinch
8	Breeds in low cliffs, stone walls. Feeds in and along streams.	white-breasted dipper, Guldenstadt's redstart
9	Breeds in bushes and thickets. Feeds on grass, in bushes and fields.	Tibetan partridge, great rosefinch
10	Breeds in bushes and thickets. Feeds along streams.	robin accentor

Table 1. Wetlands of Ladakh: habitat utilization by birds for reproduction and feeding.

For example, let us see what happens if the water levels in the pools and streams rise under flood conditions. The high water levels will:

- (a) drown the feeding habitat for 10 species from HC 2, 5, 8, and 10; and
- (b) drown the breeding habitat for 11 species from HC 1, 2, 5, and 6.

The opposite extreme of an acute scarcity of water through either drought or freezing may threaten:

- (a) the feeding habitat of 15 species from HC 1, 2, 3, 5, 8 and 10; and
- (b) the breeding habitat of 11 species from 1, 2, 5, and 6.

Maintaining steady water levels will definitely benefit the 12 species that use the wetlands for both feeding and reproduction, but will probably have no substantive effect on the remaining 16 species. The two endangered species of Ladakh, the bar-headed goose and black-necked crane, appear to benefit from constant water levels in wetlands.

If stone walls are built to protect a portion of the wetlands, grazing by livestock will be excluded. But if the grass is allowed to grow freely, the feeding habitat for birds that forage in short grass will be reduced. The birds that would be affected are bar-headed goose, black-necked crane, eastern callandra lark and yellow-headed wagtail. Tall grass may make foraging difficult for eagle owls, long-legged buzzards and red-billed choughs which all hunt for voles, lizards and large insects in shorter grass. But longer grass may be useful as breeding habitat for species such as the Tibetan partridge, and short-toed and eastern callandra larks. The stone walls may also provide more breeding habitat for black redstarts, Guldenstadt's redstarts *Phoenicurus erythrogaster*, desert wheatears, and snowfinches. Therefore it appears that if walls are built they will benefit species that are not directly dependent on wetlands more than they will benefit those that depend on wetlands.

Intensive grazing by livestock in the marsh and on low shrubs and herbs may threaten the feeding and breeding habitat of species from HC 2, 5, 6, and 9, a total of 10 species that feed in wetland habitats and low bushes. An increase of livestock wading into pools and rivers will particularly affect the nesting success of bar-headed geese and black-necked cranes. Regulated, low intensity grazing and movement of domestic animals will benefit all these species.

These generalizations, however, will have to be modified according to the breeding timetables of species, particularly the periods of peak breeding and feeding activities. The latter may be presumed to occur when birds are rearing their chicks, and a pair has to fill several beaks besides their own! The influence of water levels and grazing can be more precisely gauged if the peak periods of activity are taken into account.

Table 2 lists the 28 bird species, and the months of their feeding and reproductive activities in Ladakh wetlands. We have very little precise data for Ladakh for the period November to February. But as most wetlands remain frozen and most birds migrate to lower altitudes, the level of

avian activity must be very low. The thaw begins in early May, and as spring gives way to summer, the melting snow provides more and more water to the wetlands, raising the water levels and sometimes even submerging the surrounding meadows. Flood conditions may be reached in late July or early August. The levels recede from the middle of August through September, and more and more areas are exposed and converted to grasslands and puddles. During severe droughts the entire wetland may dry up. This water regime should be considered when evaluating the impact of various conservation measures on birds. Table 2 shows that the main reproductive activity of Ladakh birds occurs between May and July. If the thaw begins late, the wetlands will still be frozen when the birds start to nest. This may seriously affect their breeding success, as happened in 1983. Alternatively, with an early thaw wetlands are flooded in early June, and nests are likely to be washed away. Both these conditions will mainly affect island nesters and those birds that nest in wetlands and grass thickets—most of the wetland species including bar-headed goose and black-necked crane. Regulation of water levels at nesting sites is crucial during the period from May to July.

Intensity of grazing will also have to be regulated during this period. Shepherds start arriving with their animals in the wetlands at the beginning of the thaw. If the thaw is late and the birds nest on frozen ground, the wandering animals can freely approach and trample the nests. With an early thaw the island nesters may still be safe, but birds nesting in marshlands may be disturbed by wading domestic animals. Grazing will have to be controlled according to the prevailing weather conditions.

If walls are built to exclude grazing animals, their siting will have to be determined most carefully. If the thaw is late the walls will undoubtedly provide protection to birds nesting on frozen ground. But if the thaw is early, the enclosed areas may retain a higher water level and flood the nesting sites of birds that nest in marshes and grass thickets. The height of the grass in the enclosed area will also have to be controlled. Shepherds generally show reluctance to cut the grass to feed their animals. If the cutting is done by paid labor it may be costly. Selective grazing may prove to be a better alternative. Likewise, a blanket ban on grazing within a 1-km perimeter from the nest may also not be uniformly beneficial. It would be better if the manager were to decide on the spot which areas to close completely, which to close only partially, and which areas to keep open for grazing. The decision should be based on weather conditions and nest distribution on the site. It may also be worthwhile to relax controls after mid-July once the peak breeding and rearing season is over.

Lastly, let us consider how dominant plant species in different communities are used by different bird species (Table 3). It should, however, be remembered that these wetlands are situated at altitudes of over 4000 m. As weather conditions at these heights are often extreme, plant life remains sparse with only a few specialized species able to withstand these conditions. Some bird

Name of Bird	Month of Occurrence											
	1	2	3	4	5	6	7	8	9	10	11	12
Great crested grebe				F	F	RF	RF	F	F			
Bar-headed goose				F	RF	RF	F	F	F			
Ruddy shelduck					F	RF	RF	F	F	F		
Goosander					F	RF	RF	F	F			
Long-legged buzzard					F	RF	RF	F	F			
Bearded vulture				F	RF	RF	RF	F	F	F		
Tibetan partridge			F	F	F	RF	RF	F	F	F		
Black-necked crane				F	RF	RF	F	F	F	F		
Mongolian plover					F	RF	RF	F	F			
Common redshank					F	RF	RF	F	F			
Brown-headed gull					F	F	RF	RF	F	F		
Common tern					F	RF	RF	F	F			
Tibetan sandgrouse				F	F	RF	RF	F	F	F		
Turkestan hill pigeon				F	F	RF	RF	F	F	F		
Eagle owl				F	F	RF	RF	F	F	F		
Eastern callandra lark					RF	RF	RF	F	F	F		
Short-toed lark				F	RF	RF	F	F	F			
Yellow-headed wagtail					F	RF	RF	F	F			
Pied wagtail					F	RF	RF	F	F			
White-breasted dipper					F	RF	RF	F	F			
Robin accentor				F	F	RF	RF	F	F	F		
Black redstart					F	RF	RF	F	F	F		
Guldenstadt's redstart					F	RF	RF	F	F	F		
Desert wheatear					F	RF	RF	F	F			
Great rosefinch				F	F	RF	RF	F	F	F		
Blanford's snowfinch				F	RF	RF	F	F	F	F		
Red-billed chough				R	F	RF	RF	F	F	F		
Common raven				RF	RF	F	F	F	F	F		

Table 2. Reproduction and feeding periods for birds in wetlands of Ladakh. R=reproduction. F=feeding.

Name of Bird	Shallow water:	Marshland:	Wet meadows:	Waterside shrubs:	Scrub on sand:	Rocks, pebbles and stone walls	Cliffs
	<i>Potamogeton, Myriophyllum</i>	<i>Carex, Triglochin, Nostoc</i>	<i>Carex, Polygonum</i>	<i>Myricaria, Ranunculus</i>	<i>Caragana, Astragalus</i>		
Great crested grebe	RF						
Bar-headed goose	F	RF	F				
Ruddy shelduck	F	F					R
Goosander	F						R
Long-legged buzzard							R
Bearded vulture				F	F	F	R
Tibetan partridge				RF	F	F	
Black-necked crane	RF	F	F				
Mongolian plover		F		F	RF		
Common redshank		RF	RF				
Brown-headed gull	RF						
Common tern	RF						
Tibetan sandgrouse					RF	F	
Eagle owl						F	RF
Eastern callandra lark			RF	F	F		
Short-toed lark		F	F	RF	RF		
Turkestan hill pigeon					F	F	R
Yellow-headed wagtail		F	F	RF			
Pied wagtail		F	RF	RF			
White-breasted dipper	F			R		R	
Robin accentor				RF	RF	F	
Black redstart				F	F	RF	
Guldenstadt's redstart			F	F		R	
Desert wheatear				F	F	RF	
Great rosefinch				RF	RF	F	
Blanford's snowfinch					RF	RF	
Red-billed chough			F		F	F	R
Common Raven				F	F		R

Table 3. Wetlands of Ladakh: habitats and plant communities utilized by birds. R=reproduction. F=feeding.

species do not directly depend on vegetation. They breed on open ground, or cliffs or human-made structures and subsist on insects or other animals. The table shows 12 such species. These include not only birds of prey and insect-eaters such as redstart, wheatear, and chough but also wetland species such as brown-headed gull *Larus brunnicephalus*, common tern *Sterna hirundo*. The remaining 16 bird species make direct use of the vegetation either for nesting and/or feeding.

The table shows that the number of bird species nesting on cliffs and rocky plateaus is higher than the number nesting within plant communities. This is due to the peculiar situation of these wetlands. Compared to the number of species nesting in wetlands, the high number of species using waterside shrubs and scrub on sand for nesting is also significant. Among birds using wetlands for feeding and breeding, the number of species using aquatic plants for nesting (shallow water sites) is almost equal to the number using marshlands and wet meadows.

The foraging activity of most birds is concentrated in dry scrub, turf, and rocky plateaus where most of the insect and small animal food is found. Waterside shrubs are also utilized by many species for feeding activity. Among aquatic birds, shallow water and fresh and saline marshes seem to be the most important feeding habitats.

As many of the birds occurring here feed on insects and animal matter, factors contributing to the proliferation of these foods may prove beneficial. Dung produced by domestic and wild animals contributes greatly to increased insect life. A complete ban on grazing may reduce the density and variety of insects found on these wetlands. Birds of prey like owls and buzzards feed on the abundant rodents that burrow in soft earth around the marshes. While too much water may flood these burrows, too much trampling by animals may render the ground hard and make it difficult for burrowing animals to live there.

Intelligent regulation of water levels and movements of domestic animals is therefore called for. It will also be necessary to control the height of grass in certain areas to maintain bushes and herbs at the waterside, and to help regeneration of desert plants in sandy patches. All this calls for a closer and deeper study of the terrain, the en-

vironment, and of the way birds use their habitats. The manager will have to be selective in implementing the protective measures.

#### MEASURES BASED ON HABITAT USE BY BIRDS

Let us now summarize the recommendations that seem to be justified on the basis of the utilization of different habitat types by birds of these wetlands.

1. Regulation of water levels appears to be necessary mainly during the period May to July. The maintenance of appropriate water levels at different sites may be dictated by the distribution of nests, by the availability and extent of different feeding habitats, and by the number of different species of birds that utilize them.
2. Likewise it will be necessary to regulate grazing and movements of domestic animals during the period May to July. Gradual relaxation of controls after mid-July may be considered, depending on the local situation. As dung provides and encourages insect life, regulated grazing may be advisable even during the peak nesting period.
3. Rubble walls may be used sparingly with their siting determined very carefully taking into account the normal and abnormal water levels at different sites, the distribution of nests in the particular season, and the extent of different feeding habitats.
4. Protection and care of waterside and scrub vegetation including practices that encourage regeneration of such vegetation, and the planting of suitable species that are rapidly declining will also be necessary to provide adequate breeding and feeding habitat for birds.

It should be emphasized that the actual implementation of the protective measures will depend on local conditions of the terrain, the climate, and the general environment. A combination of control and relaxation may be justified. In all, a continuous monitoring of bird populations as well as a continuous study of the lives of these birds, are requisite for success. Such studies will determine the style and the content of management measures. The study of birds and the management of their habitats should go hand in hand, continually influencing each other.

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APPENDIX:SCIENTIFIC NAMES OF BIRDS LISTED IN TABLES BUT NOT MENTIONED IN THE TEXT

English Name	Scientific Name	English Name	Scientific Name
Great crested grebe	<i>Podiceps cristatus</i>	Turkestan hill pigeon	<i>Columba livia</i>
Bearded vulture	<i>Gypaetus barbatus</i>	Pied wagtail	<i>Motacilla alba</i>
Mongolian plover	<i>Charadrius mongolus</i>	White-breasted dipper	<i>Cinclus cinclus</i>
Common redshank	<i>Tringa totanus</i>	Robin accentor	<i>Prunella rubeculoides</i>
Tibetan sandgrouse	<i>Syrrhaptes tibetanus</i>	Great rosefinch	<i>Carpodacus rubicilla</i>





## WINTERING CRANES IN GUJARAT STATE, INDIA

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### ABSTRACT

This paper reviews some of the unpublished studies made on common cranes *Grus grus* and demoiselle cranes *Anthropoides virgo* and gives additional information on the status of these birds in Gujarat. A survey carried out by the Forest Department, Government of Gujarat, estimated the crane population in different districts in Gujarat in January 1984. The survey showed that 91% of the cranes were found in Saurashtra. The percentage of cranes in different regions in Gujarat was correlated with the percentage of farm land under food crops used by cranes. The principal food crops of cranes are groundnut *Arachis hypogea*, gram *Cicer arietinum* and wheat *Triticum aestivum*. The cranes forage on groundnut from September to December, on gram from January to March, and on wheat from February to March and April. The cranes feed in the crop land during morning and evening, and roost in freshwater reservoirs, river beds and on the seashore during the afternoon. Limitations on censusing of cranes at reservoirs are discussed, and censusing of cranes foraging in the crop fields by sample counts is advocated. It is estimated that there were 3.1 demoiselle cranes and 1.7 common cranes per km<sup>2</sup> in Rajkot District during November-December 1986. The proportion of demoiselle to common cranes progressively changed from 237.9:1 in 1983-84 to 1.8:1 in 1986-87. During this period, the annual rainfall declined from about 741 mm in 1983-84 to 205 mm in 1986-87. Adult : juvenile ratios as estimated in Rajkot in the 1986-87 season were 1 juvenile per 10.5 adults among demoiselle cranes and 1 juvenile per 5.5 adults among common cranes. The future of the cranes in the Saurashtra Region, the main wintering ground of cranes in Gujarat, is discussed. Saurashtra is on the threshold of rapid agricultural, industrial and social changes.

Amateur and professional ornithologists visiting Gujarat from various parts of India and other countries have marvelled at awesome gatherings of the demoiselle and common cranes at the numerous reservoirs. Some ornithologists have even written about their experiences (see, for example, Gole 1984).

Ornithologists and wildlife biologists within the state have given some attention to the cranes, but many of their studies are unpublished and, therefore, little known. The Forest Department, Government of Gujarat, conducted a survey of cranes (F.D. Survey) in Gujarat from 16-20 January 1984. The F.D. Survey report, which has not yet been published, gives the number of demoiselle and common cranes (and also sarus cranes *Grus antigone*) for every

district of Gujarat. Parasharya (1984), Anjineyulu (1984), Gopakumar (1985), Jack (1986), and Mundkur (unpublished) have also studied certain aspects of wetlands and their birds in Gujarat, and have assembled important information relevant to cranes.

The present study reviews some of the above mentioned studies and adds new information, with the primary objective of sharing our experiences with other crane lovers and scientists. We are aware that this endeavor involves more questions than answers, but we hope that the questions will provoke more intensive studies on the demoiselle and common cranes.

## MATERIALS AND METHODS

### Relative Distribution of Cranes in Gujarat

In this paper, we have utilized some of the results of the F.D. Survey of the demoiselle and common cranes in Gujarat. After careful consideration of the methods used in the Survey, which simultaneously involved a large number of forest guards looking for cranes in every district, we believe that it gives a fairly reliable gross estimate of relative distribution (actual numbers not being reliable) of cranes in different parts of Gujarat. We have, therefore, combined the data for the demoiselle and common cranes and recalculated the numbers to illustrate the proportionate representation of cranes in the various districts of Gujarat.

### Food of Cranes

Our observations of crane food were limited to watching cranes feeding in crop fields through a 30-45x telescope.

### Agricultural Crop Pattern

The data collected from two villages near the Saurashtra University campus by Patel (1987), for his studies on the food of pigeons, provide a representative sample of the crop pattern in Saurashtra. We have used these data here, relating the food of cranes to the agricultural crop pattern in Saurashtra.

### Climatic Data

The climatic data given in this paper are the mean values of the daily records made by the Aerodrome Authority of Rajkot.

### Annual Changes in the Proportion of Demoiselle and Common Cranes in Rajkot

Three reservoirs - Lalpari, Aji, and Nyari - located on the outskirts of Rajkot City, have been visited at regular intervals from 1983 onward for the purpose of taking water-bird censuses (Anjineyulu 1984; Gopakumar 1985; Joel 1986; Mundkur unpublished). Counts of cranes found resting in these reservoirs during 15 visits in 1983-84, 11 visits in 1984-85, 4 visits in 1985-86 and 13 visits in 1986-87 were available to us. Visits made during a season were almost evenly spread through the winter period.

### Density of Cranes in Rajkot District

We took a census from a jeep of demoiselle and common cranes feeding on the farm lands within about 250 m on either side of sample 50 km stretches of road (50 x 0.5 km transects) in Rajkot District during November to December 1986. At first, we counted cranes on the same stretch of road at different times of the day between 23-28 November 1986 to determine an ideal time for making the census. In the second stage, the cranes were counted once along each of five different routes in the Rajkot District at a fixed time from 24 November to 16 December 1986; each route was

a 50 by 0.5 km transect. Under the severe drought conditions of the 1986-87 season, the density of cranes from mid December onward started undergoing rapid temporal changes. It would have been meaningless to repeat crane counts on any route.

### Diurnal Changes in the Number of Cranes at a Reservoir

During years of bird watching, we have visited various water reservoirs and wetlands during different times of the day and have gained a subjective record of the diurnal variations in crane numbers. To make a quantitative sample study, we counted the number of cranes at about every 15 minutes between 0945 and 1830 on 1 December 1986 at the Veri Reservoir, Gondal, about 30 km south of Rajkot City.

### Adult : Juvenile Ratios

Juveniles are clearly distinguishable from adults until they reach advanced states of post-juvenile moult by January. The fresh first-year plumage in both species is a little browner than the adult plumage; but making distinctions in the field requires careful scrutiny with a powerful telescope.

During our crane census at the reservoirs and in the farm lands during the 1986-87 season, we counted the number of juveniles and adults separately whenever possible on 12 different days between 20 October and 27 December 1986, and once on 21 February 1987.

## RESULTS

### Migration Schedule

Both demoiselle and common cranes usually arrive in Gujarat in September and leave in March or April. We have observed the birds coming from Pakistan in August and September on the fall migration and flying over the Great Rann of Kachchh during the return journey in March, with small numbers continuing migration at least until mid May.

When the cranes arrive in September, the monsoon is withdrawing and the landscape is green. During their stay with us, days are relatively short and the average air temperature is relatively low; daily changes in air temperature are large. When the cranes leave us in March and April, the days are getting longer and the mean air temperature is rapidly rising (Figure 1).

### Food of Cranes in Relation to Agricultural Crop Patterns

In the Saurashtra region (Figure 2) of Gujarat, the birds arrive when groundnut, the principle crop of the region, is nearly mature (Figure 3). The cranes invade the crop fields when the farmers are not around and dig out and swallow the groundnut pods. At this time, they also seem to take in small quantities of pearl millet *Pennisetum typhoides* which is also ready for harvest.

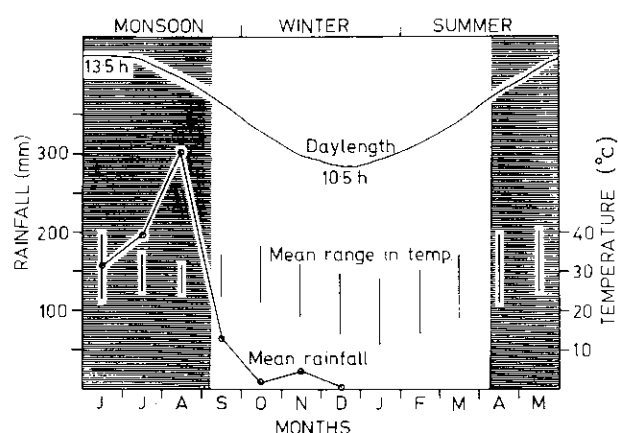
The groundnut crop is harvested in October. Farmers pull out the plants along with the groundnut pods which have matured underground. A certain quantity of pods,

however, break off and remain buried in the ground. How many of the groundnut pods are unrecovered during the main harvest is dependent on several factors, such as the hardness of the soil, which in turn is dependent on the rain pattern during the withdrawal period of the monsoon. To recover the pods left after the main harvest, the farmers plough their fields; the ploughing turns up the soil and brings the unharvested pods to the surface. When the farmers start ploughing their fields, the cranes compete with them in finding the pods. The farmers' normal practice is to plough the field one afternoon, then bring in a band of gatherers to pick up pods the next morning. If the pod-gatherers turn up a little late, the flocks of cranes may descend on the field and quickly pick up most of the pods. Even after the pod-gatherers are through picking, pods still remain in the surface layers of the loosened soil. By digging soil and turning clumps diligently, the cranes find the pods. A farmer repeats the ploughing process to recover the pods at least two to three times within a two week period. Such activities, at the district level, may continue until November or December. Thereafter, farmers find further recovery of pods uneconomical and most of the fields remain fallow until the monsoon breaks in June. The cranes, therefore, forage undisturbed in the fields after December as long as they find the pods. In the meantime, the gram and wheat crops have matured (Figure 3). The cranes invade the standing crop of gram from January to March and wheat from February to March and April.

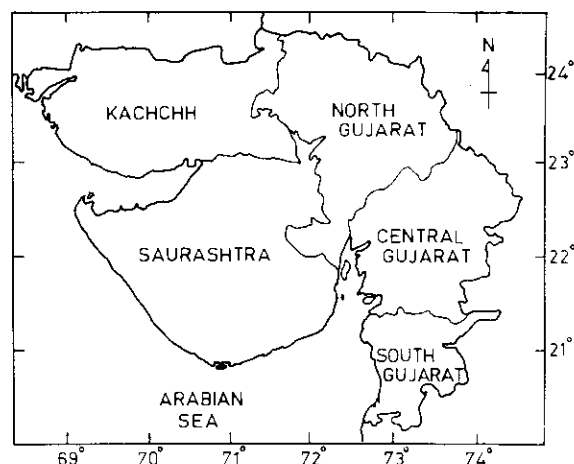
By April, most of the crop fields are fallow (Figure 3), and there is little for the cranes to feed upon. It is also time for the cranes to depart for their breeding quarters.

#### Distribution of Cranes in Gujarat

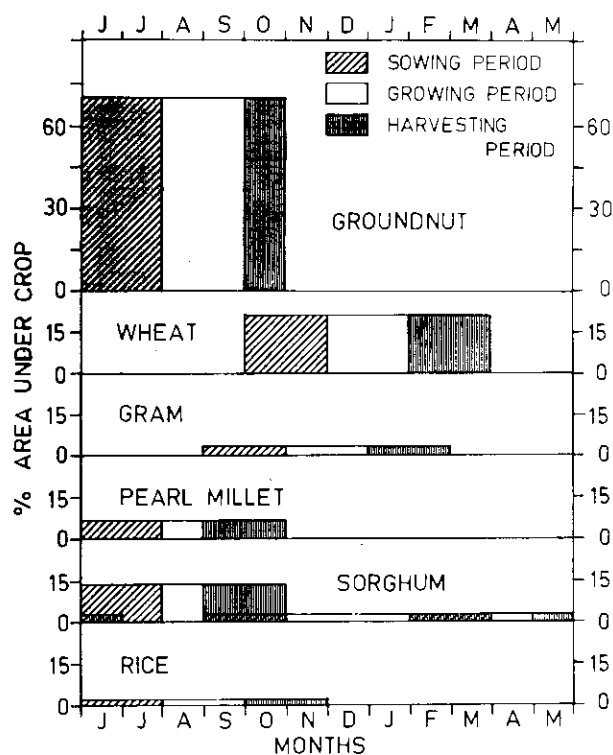
In Figure 4, we give the percentage distribution of cranes in different districts of Gujarat as revealed by the F.D. Survey. Notice that about one-fourth of the crane population in Gujarat was located in the Rajkot District.



**Figure 1.** Migration schedule of cranes in relation to climatic conditions in Rajkot. The unshaded area indicates the period during which the cranes usually winter in Gujarat. The climatic data are the average values for 1979 to 1982.



**Figure 2.** Map of Gujarat State, showing the five major regions.



**Figure 3.** Crop pattern and percent of area under different crops in farmlands near Rajkot.

Table 1 shows that 91% of the cranes in Gujarat were concentrated in the Saurashtra Region. The table also correlates the percentage of cranes with that of the crop lands under cultivation for the cranes' food crops (groundnut, gram, and wheat) in different regions of Gujarat; the correlation is statistically highly significant ( $r = 0.99$ ;  $p < 0.001$ ). The details about the percentage of areas under groundnut, gram, and wheat in different regions of Gujarat are given in Table 2.

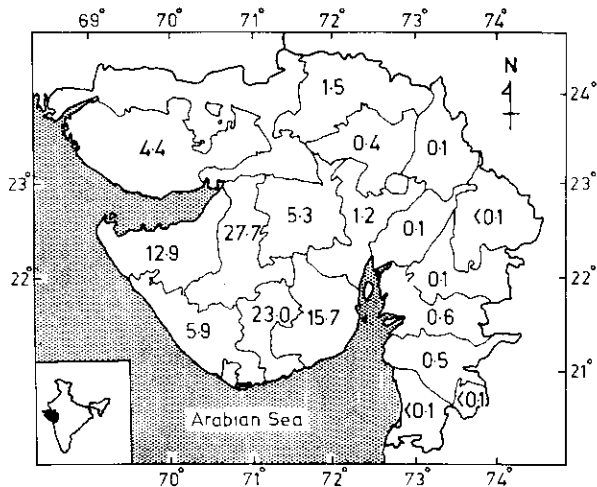


Figure 4. Percent distribution of wintering cranes in Gujarat as revealed by F.D. Survey.

#### Cranes in Saurashtra

There are about 123 freshwater reservoirs scattered throughout Saurashtra. At almost all of these reservoirs, cranes can be seen roosting in years of normal rainfall. The cranes also roost on river beds and on sand banks along the sea coast.

Saurashtra is a semi-arid region, where usually a year of poor monsoon alternates with a few years of good monsoon. Recently, however, we have experienced two successive poor monsoons, so that 1985-86 and 1986-87 were drought years, when a large number of freshwater reservoirs dried out early (December) in the season and the agricultural crops, particularly those sown in the post-monsoon period, gave a very poor yield. During these two years, we also noticed that the number of cranes wintering in Saurashtra declined, though unfortunately the decline in the population size has not been quantified.

#### Cranes in Rajkot District

Table 3 shows that from 1983-84 to 1986-87 the rainfall in Rajkot progressively decreased. The relative proportion of demoiselle and common cranes roosting at Rajkot reservoirs also progressively changed, with an increasing proportion of common cranes (Table 3). Differences in the demoiselle crane : common crane ratios during the four years were found to be statistically highly significant ( $\chi^2 = 14505.52$ ;  $p < 0.001$ ).

Table 4 shows that in 1986-87, there was on average 1 juvenile for every 11 adults among demoiselle cranes, whereas there was 1 juvenile for every 6 adults among common cranes. The difference in the adult : juvenile ratios for the two species was statistically significant ( $\chi^2 = 27.9$ ;  $p < 0.01$ ).

Region	Cropland under food crops of cranes <sup>a</sup> %	Number of cranes <sup>b</sup> %
Saurashtra	52.7	91.0
Kachchh	13.2	4.4
North Gujarat	12.4	3.2
Central Gujarat	9.5	0.9
South Gujarat	5.1	0.5

Table 1. Percentage distribution of the cranes (demoiselle and common cranes combined) and proportion of cropland under the foodcrops (groundnut, gram, and wheat) of cranes in different regions of Gujarat.

<sup>a</sup>Based on data of Shah (1987)

<sup>b</sup>Based on data of Forest Department, Government of Gujarat.

Region	Total area under crop <sup>a</sup> km <sup>2</sup>	% Cropland under <sup>a</sup>		
		groundnut	gram	wheat
Saurashtra	411,490	47.0	0.5	5.2
Kachchh	68,840	11.2	0.07	1.9
North Gujarat	301,810	2.7	0.7	9.0
Central Gujarat	211,790	3.2	1.2	5.1
South Gujarat	80,660	3.1	0.4	1.6
All combined	1,074,590	20.3	0.7	5.7

Table 2. Proportion of cropland areas under different foodcrops of cranes in different regions of Gujarat.

<sup>a</sup>Based on data by Shah (1987).

Year	Number of		D <sup>a</sup> C	Rainfall mm
	demoiselle crane	common crane		
1983-84	16,415	69	237.9	740.9
1984-85	11,998	111	108.9	579.9
1985-86	1,116	209	5.3	437.2
1986-87	8,958	4,897	1.8	205.3

Table 3. Proportion of the demoiselle and common cranes and annual rainfall in different years in Rajkot.

<sup>a</sup>D = number of demoiselle cranes.

C = number of common cranes.

Crane species	Number counted		Adult : juvenile ratio
	adult	juvenile	
Demoiselle crane	526	50	10.5 : 1
Common crane	882	161	5.5 : 1

Table 4. Adult : juvenile ratios in the demoiselle and common crane at the Nyari reservoir, Rajkot, during 1986-87 season.

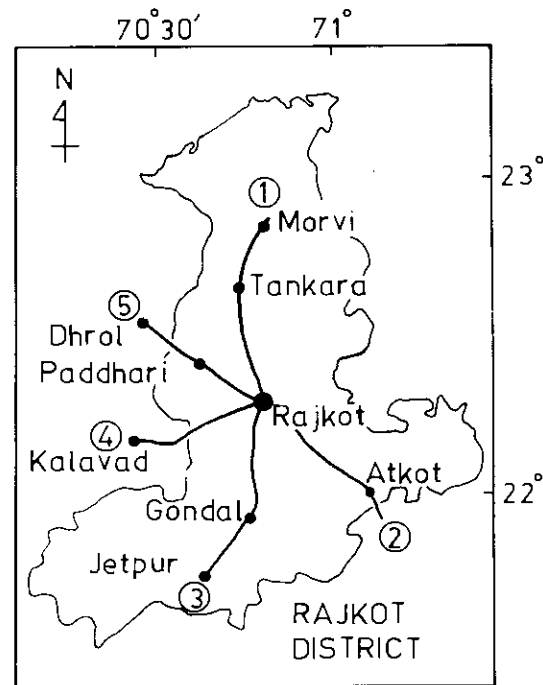
### Density of Cranes in Rajkot District

In 1986-87, we attempted to evolve a suitable method for estimating the density of cranes in the Rajkot District. To evaluate the feasibility of censusing the cranes roosting at water reservoirs, we first studied the diurnal changes in the number of cranes by making a day-long watch at a reservoir. Our counts show that the number of cranes roosting at the reservoir rapidly increased from about 1,800 to 10,000 within an hour between 0945 and 1045; a peak level of about 11,500 cranes was reached at about 1200; and the peak was maintained until 1415, when gunfire from a hunting party forced all the birds to take wing. The birds did not return until 1815 when 403 birds landed; at 1830, when we stopped observing there were 701 cranes in the reservoir as well as a large number standing in fallow fields around the reservoir. It should be clear from the above that even if cranes are counted at a reservoir around noon, events at the reservoir must be monitored prior to the count.

As the other alternative for determining population density, we took roadside counts of cranes. Table 5 gives the number of cranes that we counted along the same 50 x 0.05 km transect (route 3, Figure 5) at different times of the day. The table shows that the maximum number of foraging cranes was recorded during the 0830-1000 period. Using this time as a fixed period for the census, we counted cranes on routes 1 to 5 (Figure 5); the results are given in Table 6. The table shows that the variations in the demoiselle crane density along different routes were very high. These variations are explained by the species' tendency to forage in large flocks; therefore, its spatial distribution in the croplands of our region is not uniform. We believe that more sampling would have been desirable for estimating the density of demoiselle cranes. If we presume the estimate of 1.7 common cranes/km<sup>2</sup> along our transects was closer to the real value, the demoiselle crane density should have been 1.8 times that of the common crane (see Table 3), which works out to 3.1 demoiselle cranes/km<sup>2</sup>.

### Hunting and Predation

Farmers in Gujarat normally do not molest or kill cranes, though they do scare or drive them away when agricultural crops are threatened. The farmers' behavior can be attributed to their cultural background and predominantly vegetarian dietary habits. But, the descendants of the former ruling and martial communities, military and paramilitary personnel, and tribals shoot or trap cranes for the pot. Shooting does more damage than trapping because the cranes are usually shot while they are roosting in large congregations; when a few birds are shot, many more get injured. These injured birds are then killed by trappers who do not possess firearms. Recently, increased poisoning of cranes with pesticides and chemicals by some farmers, to deter them from entering the crop fields, has been observed.



**Figure 5.** Map of Rajkot district showing routes 1-5 along which the cranes in the roadside croplands were censused.

Time	Number of cranes		
	demoiselle	common	total
0700-0830	24	319	343
0830-1000	638	60	698
1000-1130	0	0	0
1130-1300	0	0	0
1300-1430	0	0	0
1430-1600	0	0	0
1630-1800	6	53	59

**Table 5.** Diurnal variations in the number of demoiselle and common cranes in croplands along a 50 × 0.5 km transect.

Route no.	Date	Number of cranes			
		demoiselle		common	
		total	per km <sup>2</sup>	total	per km <sup>2</sup>
1	16 December 1986	103	4.1	4	0.2
2	12 December 1986	57	2.3	77	3.1
3	24 November 1986	638	25.5	60	2.4
4	15 December 1986	220	8.8	46	1.8
5	13 December 1986	2	0.1	20	0.8
All routes combined		1020	8.2	207	1.7

**Table 6.** Number of common and demoiselle cranes counted per 50 × 0.5 km transect, between 0830 to 1030 hours, on different routes in the Rajkot district.

## DISCUSSION

Determination of adult : juvenile ratios in wintering cranes is a simple method capable of yielding valuable results. The relatively low proportion of juveniles among the demoiselle crane flocks in 1986-87 is indicative of a lower reproductive success of this species in its breeding quarters during the 1986 breeding season. In the absence of records in former times, we do not know whether the bird had low reproductive success in earlier years. If the low reproductive success has been a recurrent feature in this crane, we might expect the population size to shrink. The adult : juvenile ratio in the demoiselle and common cranes should be determined in India on a well planned and regular basis as one of the ways of monitoring population trends among the cranes.

There is also an urgency for instituting a regularly repeated crane census, even if only in a restricted region in India. Counting of roosting cranes on water reservoirs appears to be a frequently used method of crane census. Our studies, however, show that the method has severe limitations. The cranes have to be censused around noon; in the cooler weather of late December and January, we have known the cranes to forage for longer hours and roost for a relatively shorter period at mid day. Furthermore, events at the reservoir prior to the census time must be known, or better still, the disturbances to cranes at the reservoirs selected for census should be stopped. Obviously, we would need a small army to census roosting cranes in a region like Saurashtra, where there are over a hundred reservoirs (Rajkot District alone has 46 reservoirs) besides an undetermined number of seashore and river bed sites for roosting cranes. Under such conditions, sample counts of the foraging cranes, similar to what we had taken, but with a larger sample size, should give a reasonably good estimate of the population size.

We have noted a progressive decrease in the proportion of demoiselle cranes and a consequent increase in the proportion of common cranes for the Saurashtra Region from

1983-87. This change raises a number of questions. Has the number of demoiselle cranes visiting this area been decreasing or has the number of common cranes been increasing? Does the progressive increase in aridity of the region have a "cause and effect" relationship with the changes in relative numbers of two crane species, or have the two phenomena been merely coincidental?

Another poorly known aspect of the two crane species is the way in which they minimize competition for food and roosting places in the wintering quarters. Though both crane species may feed in the same crop fields and may use the same roosts, our preliminary observations indicate that there are subtle differences in the manner in which the species utilize the resources in their wintering habitat. For example, the common crane forms relatively smaller foraging flocks, does relatively more digging and less walking while foraging, and roosts in relatively deeper water.

While we know what agricultural crops the cranes exploit most commonly, we know very little about other foods they are capable of utilizing. Once, we were surprised to find several common cranes feeding in a standing crop of cotton. The farmers maintain that the birds eat immature cotton bolls, which very few vertebrates are known to eat.

Several lacunae in our knowledge of the cranes urgently need to be filled. Saurashtra, long considered a good wintering ground for the cranes, is on the threshold of rapid changes. A steady decline in the yield of groundnut crops during the last few years (apparently because of monoculture year after year) has made the farmers turn their attention to alternative crops such as soybean *Glycine max* and sunflower *Helianthus annuus*. A large network of irrigation canals will start bringing water to Saurashtra from a large perennial river in central Gujarat within a decade or two. Furthermore, a plan for rapid industrialization of the area is on the anvil, and traditional cultural values of the people, which have contributed greatly to the success of cranes, are rapidly eroding under the influence of westernization. If we are to help the cranes during changes that are coming to our region, we must know more about these birds.

## ACKNOWLEDGMENTS

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# THE FUTURE OF CRANES IN PAKISTAN WITH SPECIAL REFERENCE TO THE NORTHWEST FRONTIER PROVINCE

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## ABSTRACT

Wetlands of Pakistan fall on the migration route of three species of cranes: common crane *Grus grus*, demoiselle crane *Anthropoides virgo*, and Siberian crane *Grus leucogeranus*. Cranes use the northern frontiers of the Northwest Frontier Province (N.W.F.P.) and possibly those of Baluchistan to enter Pakistan and reach their ultimate winter resorts in Pakistan or India. The overall population of cranes that pass through Pakistan or winter here is not yet known, but hundreds of birds are trapped each year by a traditional but unique method in N.W.F.P. Previously, there were no regulations or controls over crane hunting; but for the last few years, measures have been developed and adopted by different provinces, especially N.W.F.P., to safeguard against large-scale and unrestricted hunting of these birds. These measures, along with suggestions for future conservation of cranes in Pakistan, are discussed in this paper.

## INTRODUCTION

Two crane species are frequently seen in Pakistan when they migrate through in the fall and spring: the common crane and demoiselle crane. Common and demoiselle breed in Central Asia and migrate southeast in autumn to their wintering grounds in India. A third species, the Siberian crane, quite rare throughout the world, is also believed to pass through Pakistan although sightings have not been definitely confirmed.

Exact population figures are not available for individual crane species, although demoiselle cranes are believed to pass through Pakistan in greater numbers than the common cranes. Their combined population is estimated to be around 40,000.

Through centuries, people living in certain areas of the N.W.F.P. of Pakistan have hunted the migrating cranes in a specific traditional way. A weighted cord is used to snare cranes that try to land in response to calls of caged and trained vocal pairs of cranes during the night, particularly in bad weather.

This practice has several interesting features. Crane hunting is a local tradition and is a symbol of social status. Cranes are good pets and add to the beauty of lawn and courtyards. Cranes are considered to be responsible watchers and will not allow strangers to enter their owner's houses. These birds are given alive to honored guests, and can be sold for good return. Crane hunting is a good hobby for people not having much to do.

Crane hunters, in addition to snaring live cranes, use guns to shoot cranes. The two methods are sometimes used together. But in areas where cranes are trapped alive, guns

are disliked because chances for catching alive birds become less where guns are frequently used. Shooting with guns is mostly practiced in Parachinar valley.

A survey was conducted in different parts of the country for three purposes: 1) to estimate the number of birds trapped alive or killed; 2) to identify the sites where cranes winter or stop for some time; and 3) to assess the threats to the cranes' survival. Information was collected from the people acquainted with the sport hunting of these birds.

Sufficient headway has been made to regulate the hunting of cranes through legal measures, the effectiveness of which has been assessed. This paper discusses ways to improve further the conservation measures, so as to secure the future of cranes while passing through Pakistan.

## MIGRATION AND WINTERING

Since scientific data are not available, exact routes and corridors used by cranes for entering and leaving Pakistan are not known. Cranes have often been sighted, however, in different places in Pakistan, either in flight or during short rests (Figure 1). Moreover, crane hunters have long used certain sites in the provinces of N.W.F.P. and Baluchistan for catching cranes in autumn and spring. These sites are visited by cranes and indicated on Figure 2.

In southern parts of Pakistan, the majority of the cranes are seen on River Indus between Taunsa barrage and D.I. Khan and on small rivers west of Indus like Zhob, Luni, Kashu, and Kurram flowing through the districts of Zhob, D.I. Khan, Bannu, and Parachinar respectively. The available catch data in the above areas further suggest that

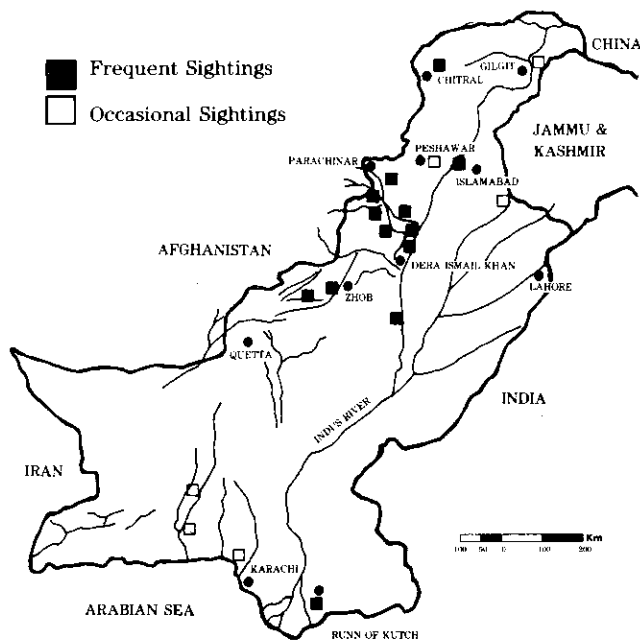


Figure 1. Crane sighting records in Pakistan.

while large numbers of cranes use these rivers during their return journey in spring, these routes are used for entry in autumn only by about 10% of the crane population. It has also been observed that common cranes and demoiselle cranes use different sites during migration. Common cranes are more common on River Indus while demoiselle cranes are largely seen on Luni, Kashu, and Zhob. Farther north in Parachinar valley, both the species are seen, roughly in equal numbers. Field reports and interviews with hunters in Parachinar reveal that cranes are difficult to hunt here in autumn as they do not land, and fly at considerable height. Similarly, the flocks that pass over River Indus during the inward journey in autumn are believed to be much smaller than the crane flocks going back in spring. The above facts suggest that different routes are used by cranes during the two migrations.

Cranes are also sighted in northern Pakistan, especially during the autumn journey, at places like Chitral and Baltistan. Although the number of cranes passing through the above area is not known, these sightings suggest that some populations of cranes might be using this route for reaching their wintering grounds in India without passing through the rest of Pakistan. These same cranes may join other cranes during the return journey and thus form bigger flocks in spring.

Cranes have not been reported wintering in Pakistan until recently. Two groups of less than 80 were seen for the first time in January, 1987 on Taunsa barrage in the Province of Punjab and on a lake in Badin District of Sindh. Total length of stay for cranes on these wetlands, however, could not be ascertained. Both the wetlands are protected and hunting of cranes is particularly prohibited. Cranes have also been sighted in small groups on various sites of River

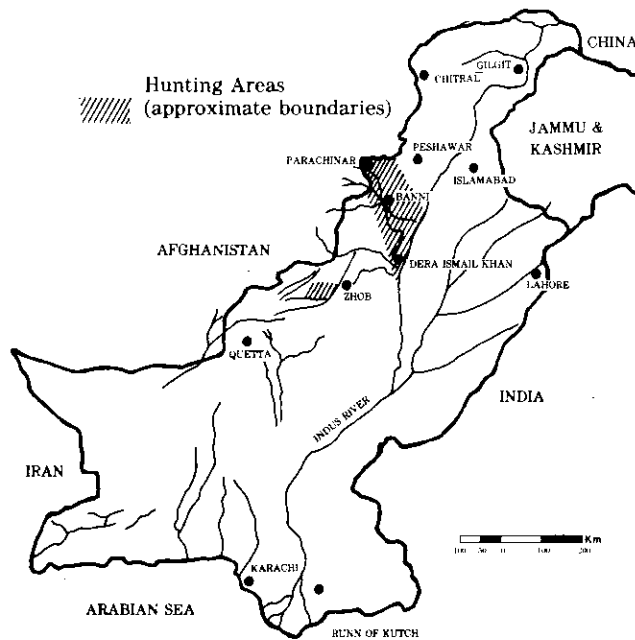


Figure 2. Crane hunting areas in Pakistan.

Hingol in the southern part of Baluchistan. A group of about 200 was seen in flight near Sonmiani Beach in February, 1986.

Information on sighting of Siberian cranes is imperfect and not worth mentioning.

#### HABITAT

Although a network of wetlands is available through the entire length and breadth of Pakistan (Figure 3), cranes have not been reported using them as wintering grounds. The sites used by cranes as stopover places during their migration are vast river beds with succulent vegetation of first successional stages. *Tamarix dioica* was found to be the dominant plant species followed by grasses, *Typha* and *Phragmites* on such sites depending on the duration of inundation at different levels of the river flow. Groups of cranes, up to 200 in number, can normally be seen between 1700 and 0900 during March on these beds. Cranes generally stay on sites that provide good visibility on all sides and that are difficult to approach. Period of stay on such sites is not confirmed, although it is believed to be less than a week.

#### THREATS

There are two major threats to the survival of cranes in Pakistan.

##### Hunting

As mentioned before, cranes are hunted in two ways: they are trapped alive and they are shot. Figures collected

from various sources suggest that about 5,000 cranes are either caught alive or shot annually in the provinces of N.W.F.P. and Baluchistan. Although it has not yet been possible to determine the exact population of cranes, data based on hunters' reports indicate that 10-15% of the total cranes passing through Pakistan are taken each year. At this rate, the population of cranes could be estimated at around 40,000.

From the above estimates, it appears that the present rate of hunting is quite high. Furthermore, the sport is increasing with the recruitment of new hunters each year. The number of hunters has grown by about 500% over the last 20 years. Hunting pressure has accordingly increased.

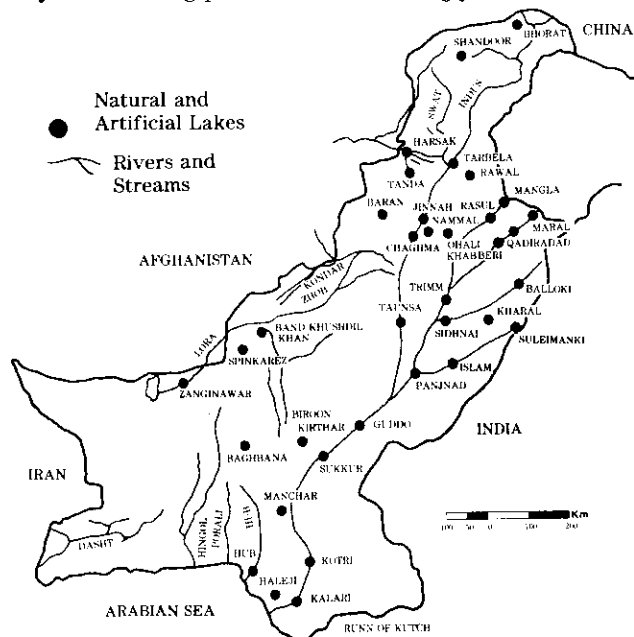


Figure 3. Pakistan's important wetlands.

#### Habitat Loss

Although quite a few wetlands, areas that could be used by many species of birds, have been created in Pakistan in the form of dams and barrages, such structures have ended the normal and routine process of inundation of the rivers. Floods are minimized, and as a result old river beds have been converted into agricultural fields and villages. The vast wilderness areas of the past few decades now have networks of roads and electric cables. The dark, calm and quiet nights of the past now glitter with electric bulbs and rumble with the noise of automobiles.

In response to such changes, cranes have abandoned several old sites. Whatever places are left may be sufficient to accommodate the migrating cranes for rest and food, but the places are full of hunters' camps. Hardly any flock is left undisturbed. Several flocks come near to the ground for landing on their old sites but are compelled to fly up again to continue their journey without rest and feeding. Encroachment by increasing human habitations threatens further reduction of the available habitat. If not checked, habitat loss combined with tremendous hunting pressures may ultimately cause the extinction of cranes in Pakistan.

#### Present Conservation Measures

The threat to crane populations was first understood in 1982 when a preliminary inventory of crane hunters and their camps was conducted by the N.W.F.P. Wildlife Department. Since then, various steps have been taken to safeguard against indiscriminate hunting of cranes in N.W.F.P.

#### Legal Protection

Prior to 1982, there was no control over hunting of cranes in N.W.F.P. Licenses were not required for catching cranes, and large numbers of cranes were hunted without any obligation. The only fee was for possession of cranes at a charge of Rs. 10/- per bird. In order to regulate the hunting, new rules were provided in 1984. According to these rules, every party is charged Rs. 1,000/- per camp fee and Rs. 50/- for possession of each crane.

#### Protective Staff

Wildlife protection staff is now made available during the season to check hunters' camps. Motor boats are available for this purpose on some rivers. Check posts have been established where hunters are checked for hunting permits and illegal birds.

#### Mass Education

Films and slides are now available to show to concerned groups and policy makers. One of the films has been produced locally, while the other was produced in the United States. Repeated approach to hunters by the wildlife staff for recovery of the fees for camps and pet birds has helped hunters to realize the finiteness of the resource.

#### Research

A gentlemen's agreement exists between the hunters and the N.W.F.P. Wildlife Department whereby a few live birds are donated to the wildlife staff for banding and releasing. The practice has been of small scale and aims at finding the migration routes of cranes. But no band has been returned so far.

#### Other Provinces

Crane hunting is not allowed in the other provinces of Pakistan. Fortunately, cranes are not hunted in the provinces of Sind and Punjab but hunting does occur in Zhob district of Baluchistan, mainly by hunters from Bannu district. Since this practice is a violation of standing rules, the wildlife staff of Baluchistan raids such camps and imposes fines. Money received in the form of fines was Rs.11,000/- during 1985-86 and Rs. 7,000/- in 1986-87.

#### OUTCOMES

It is apparent from the above discussion that since 1982, considerable efforts have been initiated for the conservation of cranes by local wildlife departments. How effective have these efforts been?

Crane hunters of Bannu district, belonging to the Wazir, Khattak, and Marwat tribes, have developed a hunting craze to the extent that it is almost impossible to stop them from hunting. Most of these hunters have inherited this passion from their forefathers and it is not uncommon to see hunters with more than 50 years of hunting experience. They leave their jobs and families for about one month. It involves considerable expenditure to transport camps and vocal pairs of cranes to sites that are miles away. Food charges for the camps are extra. Some of the hunters are, of course, wealthy and can afford such luxury, but the majority are poor and stay in camps at the expense of others. Overall expenditure on camping for a month or so ranges between Rs. 500/- to 1,000/- per person. Normally 15-20 persons form one hunting camp. On average, Rs.20,000 are spent by each party in a camp during the hunting season.

In view of this large sum spent by the hunting party, an additional amount of Rs.1,000/- as a camping license does not seem to discourage hunters. If they can afford Rs.20,000/- as normal expenditure, an additional amount of Rs.1,000 can also be tolerated.

Similarly, charging of Rs. 50/- per bird in possession does not discourage hunters. At the minimum, a captive pair is sold for Rs. 200/-. A crane has great value as a gift. Even if one eats the bird, the cost is recovered. Similarly Rs.50/- is the fee charged for each trained vocal bird which takes five years to train. Such pairs can bring a handsome return of Rs.20,000 -50,000. The new rules have certainly helped the wildlife department to get additional revenue for every crane hunted, as Rs.50,000 - 75,000 is annually collected through these licenses. But the new rules have not reduced the number of crane hunters.

Similar is the situation in Baluchistan. For the last two years, Rs.18,000/- have been realized by the wildlife department in the form of fines, but hunters are still there as the rules are not enforced effectively.

So far, definite education programs have not been started with clear objectives. Results are thus not obvious, because there has never been a cry on the part of the public forcing the government to stop this game, or at least minimize it.

## FUTURE CONSERVATION STRATEGY

### Protected Area

River Indus around D.I. Khan provides one of the best attractions to migrating cranes. A careful estimate reveals that a minimum of 1,000 cranes are hunted on this site. It is not unusual to see 100-200 cranes on river beds each day staying for a short rest during spring. The birds that stop here, taking sufficient food and rest, may not need to stop anywhere else in Pakistan on their return journey. But finding widespread disturbance here and all along their route, they do not have the chance to feed and rest and are compelled to take unusually long journeys to get out of Pakistan. Besides cranes, this part of Indus also provides good wintering habitat for several species of ducks and geese.

In view of the wildlife values, the N.W.F.P. Wildlife Department has decided to declare about 810 km<sup>2</sup> along a 95-km length of River Indus as a crane reserve. Hunters, who traditionally camp in this area, have already been informed of this decision. Fortunately, many of the crane hunters are becoming conscious of the dwindling of the crane population; they understand that they may have nothing left to hunt in the coming few years. Such understanding certainly helps the wildlife department to stop hunting completely in the crane reserve. By establishing the reserve, 1,000 cranes will be saved each year and many more will be provided with better escape opportunities and a safe resting area. To enforce effectively the provision of the game reserve under the law and also to improve the conditions for attraction of cranes, the government of N.W.F.P. is considering a development project through which the protective staff will be strengthened.

### Ban on Gun Shooting

Some hunters believe that guns take a heavier toll of cranes than the traditional trapping. Although it is not permissible to shoot cranes with guns, still many people spare no chance to gun down as many cranes out of the flocks as possible, especially during dark nights.

In Parachinar valley, where shooting with guns is a common practice, complete control over gun shooting may not be practical, especially in the tribal areas. Banning of guns in the camps will, however, help to save more than 1,000 birds each season.

### Restriction on Outside Hunters

The government of Baluchistan had once banned the entry of crane hunters to crane areas in Zhob district. Unfortunately, enforcement did not continue for long. Once again the government is considering strict enforcement, prohibiting the entry of outside hunters. Since the locals in Zhob do not indulge in the hunting hobby, the banning of outsiders could save more than 500 cranes each year.

### Public Education

During 1986, a joint program for the establishment of wildlife clubs in various schools was initiated by the Wildlife Management Branch of the Pakistan Forest Institute and the U.S. Fish and Wildlife Service. It is planned that more attention will be paid to schools of Bannu and D. I. Khan, in order to influence hunters through their children.

### Regulation of Hunting

Rules regarding hunting of cranes in the province of N.W.F.P. are also being revised, with main emphasis on imposing a bag limit for each hunting unit.

### Improvement of Strategy

From the above plans, it can be visualized that recently cranes are receiving far more attention in Pakistan than in previous years. Local wildlife departments and research organizations have initiated several new measures relating to crane conservation. But still there are some fields where expert advice and practical cooperation on the part of other interested countries and international organizations can be sought.

Data are needed on populations of individual crane species migrating through Pakistan, both on the crane breeding grounds and on the wintering grounds. These figures can help in evaluating the number of birds that are lost during migration through Pakistan.

Attempts have been made to band and release cranes in N.W.F.P. The number has been small so far, but this effort will grow in future years. Reports of sightings of such cranes in other countries can help to define the routes of migration. We lack an equipped banding station for cranes, and must rely on hunters for getting birds to band. It will be of great benefit if assistance is given in establishing a banding center, equipped with safe catching devices and other essential materials.

The proposed crane reserve on the River Indus has to be developed to meet the essential requirements of the migrating cranes. We will need expert advice on needed operations so as to draw up a management plan for the area.

Public education is the most essential requirement of any conservation program and cranes are no exception. Unfortunately the required educational materials and desirable techniques are not widely available. The education effort needs to be developed on modern lines for effective contribution to the cause of conservation.

### CONCLUSION

Cranes have been hunted indiscriminately in the past. Despite the control measures taken, hunting continues. After analysis of the situation, fresh plans are being prepared that will help hundreds of cranes to survive their migration through Pakistan. Such efforts could be more fruitful if international organizations cooperate in the conservation task. We are optimistic that cranes have a bright future in Pakistan, and that this resource will be conserved for the pleasure and education of the present, as well as future, generations of Pakistan.



# THE SIBERIAN CRANE IN IRAN

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## ABSTRACT

This most endangered population of Siberian cranes *Grus leucogeranus* has been observed from 1984-87 on its wintering grounds on the Caspian littoral ( $36^{\circ} 40'N$ ,  $52^{\circ} 60'E$ ). In view of the endangered status of this population, the first object in studying this almost static number of 9 to 12 birds is to devise a plan for their protection and propagation. This paper describes results of investigations into (1) migration behavior, and the size and composition of each year's population; (2) ecology of the winter habitat and exact location of territories used for feeding and resting; (3) feeding ecology of the Siberian cranes in this wintering ground on the flooded rice fields at Fereidoonkenar, Mazandaran, and identification of related flora; and (4) local conditions prevailing in this restricted area of "ab-bandans" (closed flooded fields). These fields are managed by the village waterfowl trappers, with the Department of Environment's authority being only nominal in one area. Access to the study area is controlled by the trappers, who dislike disturbance by strangers due to the trapping tactics, and also dislike any association with foreign prospects due to the political situation. Finally, viability of protection and propagation plans will be discussed.

## INTRODUCTION

This small group of Siberian cranes, discovered on its wintering grounds on the Caspian littoral a short nine years ago, has never been studied before. This research paper is based on observations during 1984-1987 of this population in the flooded ricefields of Fereidoonkenar, in the province of Mazandaran, Iran at  $36^{\circ} 40'N$ ,  $52^{\circ} 60'E$ .

## AREA DESCRIPTION

This area, located 2-3 km from the town of Fereidoonkenar, consists of a series of "ab-bandans" - i.e., enclosed plots of flooded ricefields - within a total area of 80-100 ha where tens of thousands of waterfowl are attracted each winter by the abundant food supply and the relative safety of this trapping system of "damgahs." Damgahs are trapping stations in the shrubbery surrounding the ab-bandans, where trapping of the waterfowl is done by an ingenious netting method, not by shooting. The most spectacular and important visitors among the herons, ducks, geese, and waders are the dozen Siberian cranes. The Department of Environment of Iran has some authority over the area (see Figure 1).

## OBJECT OF STUDY

It is important to determine the current status of this almost static number of 9 to 12 Siberian cranes in order to devise a plan for their protection and propagation; they comprise the most endangered population of Siberian cranes in the world. This flock is threatened not only by the changing nature and ecology of the habitat, but even more profoundly by its inbred strain. The latter problem can only be resolved by introduction of new genetic

material into the flock. This study provides a basis for conservation programs. Emphasis has been on feeding ecology, territorial and migratory behavior of this flock, and on attitudes of people and authorities involved in the future of this precious population.

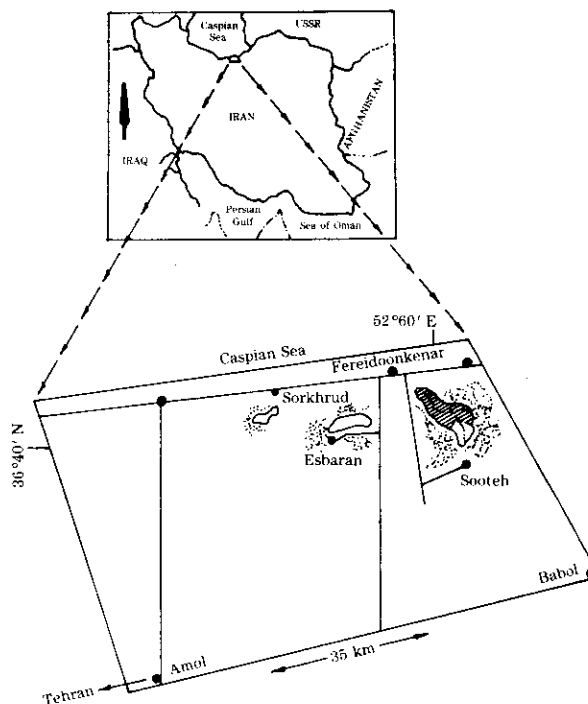


Figure 1. Winter area of the Siberian crane in Iran.

## MATERIAL AND METHODS

Observation was conducted during three past winters, most regularly in the current season of 1986-1987, from November to March by binoculars and telescope. Slides and film were taken for later analysis. Other ab-bandans in the area were surveyed. Vegetation and water samples from the feeding sites were collected for identification and analysis. Local people - trappers, townfolk, Department of Environment officials, and some authorities in Tehran - were contacted with the formation of a responsible body for the protection of this local population of Siberian cranes in mind. Being a resident of a nearby place and a long-time employee of the local university has facilitated these relations, but by no means made them easy. The post-revolutionary and war conditions have changed organizational and societal structure and priorities, all being in an amorphous state of flux. The matter of white cranes has appeared rather irrelevant and bizarre.

## HISTORY

In earliest reference to cranes extrapolated from archaeological records of names of birds in ancient languages (Salonen 1973), Landsberger identified the common crane *Grus grus* as very prevalent in fall and spring migrations in Mesopotamia, but also he quotes "a small part wintering in the marshes of the Persian seaside (Meerbusen);" if this referred to the Caspian Sea instead of the Persian Gulf, it could have meant white cranes, as common cranes are not seen wintering on the Caspian littoral today. Otherwise, among the first naturalists' reports on the wildlife of Persia was C. Hablitzl's observation of Siberian cranes in the rice fields of Gilan province in 1773, in December. This report was the only definite sighting on the wintering grounds in Iran until the flock's re-discovery 200 years later on their present site in Fereidoonkenar in 1978, by Ash-tiani (1987). There was some reference to them by Zarudnyi in the beginning of the century (Birula 1912), and of migrant birds only three documentations by Radde and Walter (1889), Floericke (1897), and Nielsen and Speyer (1967) (fide Sauey 1985) on the west side of the Caspian. The 1978 record and my sighting the flock of 10 Siberian cranes leaving Fereidoonkenar on 5 March 1985 were among the first records verifying the size of the flock. J. Mansouri, Department of Environment ornithologist, counted 14 in 1977 (pers. comm.). No research has been done on this flock, except for summary reports on their numbers, until I started observing them three years ago. Thus, the most reliable information has to be sifted from the accounts of the local people, namely the oldest farmer-trappers of the ab-bandans.

The rainy lowlands of the subtropical Caspian littoral are blotted with marshlands and within these marshes, numerous ab-bandans are fenced by farmer-trappers for trapping of waterfowl in the winter months. The practice increases in the direction of increasing rainfall - i.e., from east to west, from Gorgan to Gilan (with 450 mm and 2000 mm annual precipitation respectively). These lowlands

were covered by primeval forests until recent times, having been cleared for cultivation gradually all across the coast within the past 50-100 years. There were always natural ponds where waterfowl congregated, but the practice of ab-bandans must have been on the increase only for the last two-to-three generations of farmers. The custom is only nowadays declining, as sons are not following so faithfully in the footsteps of their fathers.

It should thus be assumed that flocks found in Gilan 200 years ago moved west within the past 50-80 years to find perhaps a more secure winter habitat. This speculation fits with the stories of the elders who inherited their "trade" from their fathers. Given the presence of waterfowl in the millions until only a score of years ago, the growing numbers of farmers devised systems for harnessing this food resource by using the ab-bandans in many ingenious ways, shotguns being all but unavailable.

The trapping methods vary from overhead nets to mid-night clubbing from boats, with some sporadic shooting; guns are allowed around the ab-bandans only at the end of the season. The most sophisticated method is the one practiced in the Fereidoonkenar ab-bandan, called the Damgah (which consists of numerous small damgahs or trapping stations). Only two other places, Sorkhrud and Esbaran, use the same method, namely catching the waterfowl by a "tame-duck-feed-into-nets" system, which is a kind of conservation-management system at the same time. Essentially, this method provides forage-filled havens hidden in shrubbery acting as blinds, where hundreds of thousands of waterbirds spend most of the winter or use them as stopovers; the birds find here a sense of safety, as the trapping goes on only at the periphery of these pools. Tame ducks are flown out into the pools to tempt the flocks of wild duck to follow as these decoy birds land back into their home pools, where a net descends on the unaware flocks.

It is in the center of these pools that the Siberian cranes have also found their haven for winter. The oldest trapper, Haji Fekri - just retired at 72 and leaving his sons to care for his damgah - remembers seeing the Siberian cranes for at least 40 years, careful to qualify his recollection as the time he recognized the birds apart from the great egret *Egretta alba*, with which the cranes are often confused. He also recalls the flock as being smaller in earlier times, quoting his father as having mentioned that at first there were only 2-3 cranes; this would place the Siberian crane in Fereidoonkenar about 80 years ago, if taken as fact.

Haji Fekri recalled only two casualties during the years, as the trappers tend to feel friendly towards the cranes; also, the cranes have proven untrappable. It appears then that this dozen or so individuals are a relic flock of an unknown number of Siberian cranes that may have wintered in various areas of northern Iran in times past, and relatively recently adopted this isolated pocket of wetlands in Fereidoonkenar as their winter refuge.

## SIZE OF THE FLOCK

Reports on the numbers of Siberian cranes in Fereidoonkenar have been acquired along with annual water-



fowl counts - often perfunctorily conducted with inadequate personnel - or on visits by experts in the area. The counts are based on (to my knowledge) one time *in situ* observations since 1978, making them inconsistent and inaccurate (Sauey 1985). This is explainable by the nature of this complex of numerous little damgahs and by the territorial behavior of the Siberian crane.

In addition, research activities of the Department of Environment and university staffs have been limited for the past eight years since the revolution, specialists like ornithologists being involved in more urgent work including increased practical problems of personal nature. I myself had to leave the university in order to engage in this time consuming research. In observing the Fereidoonkenar flock during the past three years 1984-1987, my first surprising result came purely by luck, when I arrived at the site within a few minutes of the departure of the complete flock and was able to get a photographic record of ten Siberian cranes, on 5 March 1985 at 0900 hours. Previously I had only seen groups of two and three birds, adding up to five on any given day.

The next season, 1985-1986, I covered the area more thoroughly, including the whole Damgah area, and verified 11 Siberian cranes at the time of their leaving, although I missed their departure (one bird dead in the marsh was also reported by an unreliable trapper).

This past season, 1986-1987, again 11 cranes returned, most likely the same individuals, with two juveniles of the past season and one lonely bird. After their arrival, for some time, I was able to verify only eight until late December; later an old trapper at the nearby Esbaran damgah informed me that each fall he sees 2-3 cranes there in the beginning of the season. Esbaran is the same type of ab-bandan but half the size (40 ha) of the main damgah, and in a more secluded area.

Thus, I can report, with relative confidence, that the Iranian population, after its discovery in 1978 with 11 birds (Ashtiani 1987), has never consisted of any more or less than 9-12 individuals. This number is consistent also with the earlier numbers of birds reported stopping at the Astrakan Reserve north of the Caspian Sea each year since 1928 (Sauey 1985). The mid March dates of Astrakan sightings also correlate with the now known departure time of the Fereidoonkenar flock in early March (see Table 1).

## MIGRATION BEHAVIOR

The spring departure of the Iranian flock was first verified on 5 March 1985 at 0900-0930 hours. As I arrived on the scene, 10 Siberian cranes were circling over the center of the Damgah singing farewell to their winter habitat in what I then described as a double-note "oo-ook" call in a-flat tones. Then the 10 cranes gathered and rose in the clear skies, taking direction toward the west while still calling. Their direction would lead them along the coastline, turning north in Gilan toward the assumed stopover at Astrakan Reserve north of the Caspian Sea in the Soviet Union. It was a cold but sunny day, about 10° C. The next spring they disappeared on 4 March 1986, but I missed the moment of departure. The weather was unclear after a heavy rainstorm the previous day during which I had witnessed a family group feeding in the rain in their territory (B/o); therefore I didn't visit the site on 4 March, and on 5 March they were gone. As usual, some trapper related how the cranes gather together at the last damgah and "sing and dance" a day or so before leaving. Were they deflected by rain from "normal behavior" in 1986? During spring 1987 I watched both weather and date, trying to witness the predeparture rites for sure. While the previous February ended in a bout of mild *ca.* 12° C weather, this year winter had been very warm through January and February, often hitting 20° C during the day, while nights may have dipped to near zero. I was *in situ* on 23 February on such a day, observing territory A with the single bird (Solo), one family (Trio) and one pair (Duetto). In territory E/o the trapper related how he saw "his group" of cranes circle the area and then rise up to the sky "to leave." I didn't believe him, as it was over one week to the beginning of March, which turned cold and stormy. But 24-25 February were balmy days up to 24° C, and it was apparently then that the whole flock had disappeared, according to the trappers. This time, however, no one had seen all of the cranes together circling and calling. There was a rumor that a young trapper had caught one of the juveniles, which I had no way of verifying. But on 23 February I had noticed the noise of tillers in the fields, as farmers had started early their spring work, and there were sounds of shooting far in the background. All these factors must have lead to the early departure.

Place	Arrival date fall	Departure date spring	Territorial groups- division	Number in fall	Number in spring
Fereidoonkenar	1977	1978			11
	1978			Conflicting reports	
	15 (?) November 1984	5 March 1985	2,2,3,3 or 2,2,2,3,1		10
	(?) November 1985	4 March 1986	2,2,3,3,1	11 (+ 1 ?)	11
	7 November 1986	25 February 1987	2,2,3,3,1	8 + 3	11 (?)
Chahrmahal-e-Bakhtiary	1986	-	Doubtful report	2	

**Table 1.** Numbers and migration dates for Siberian cranes on the Caspian littoral, Iran.

The fine for killing a Siberian crane is 30,000 rials (a worker's monthly salary), but only a few days' lucky catch for a trapper, and who would impose the fine these days?

In summary, the Iranian flock departs between the last week of February and the first week of March, coinciding approximately with the migration time of the Indian flock (Sauey 1985). The fall migration time of these Siberian cranes was first verified to the day this past season, the flock arriving on 7 November 1986 in very warm weather over 20° C, conditions which prevailed a few more days. According to the trappers' accounts, the flock descends to feed together for a few days in the ab-bandan, but a week later they were already in territorial groups conforming to the composition of the previous season. This I didn't verify, however, until mid December.

In the fall of 1984-85 season I observed the first cranes on 17 November, already in territorial groups, having arrived around 15 November, again to credit trappers' accounts (see Table 1). In the fall 1985 no records were obtained.

Thus, it appears that the cranes arrive in a flock within the first two weeks of November. There has been only a one week difference observed in the annual arrival and departure time (during the past 3 years).

## TERRITORIAL BEHAVIOR

### Territorial Groups

The 11 Siberian cranes of the past two winters of 1985-86 and 1986-87 were divided into territorial groups by the same pattern, namely: two families, two pairs, and one lonely bird (3,3,2,2, and 1). The composition of the 1984-85 flocks was probably 3,3,2,2, (or 3,2,2,1); I observed only two territorial groups that winter and then the departure of all ten together. The two juveniles in the past two winters' flocks indicate a reproduction rate of 2 per year, counteracted however, by the same attrition rate, as the size of the flock has remained about the same. Juveniles retained brownish neck and head and buff primary feathers until their spring departure time, with red beaks but not yet distinctly red legs.

### The Territories

The 11 Siberian cranes that departed in spring 1986 returned in equal numbers the same fall to claim about the same territories each group had used the previous season, with some overlap areas. This territoriality has apparently been long established, as sightings usually have referred to groups of two and three. Antagonistic territorial behavior is displayed relatively seldom, mainly right after arrival as the territories are being re-adopted.

In the beginning of the season, when the food is abundant everywhere, the cranes tend to feed among water-fowl flocks inside the damgah, in the many secluded spots in the interwoven patchwork of shrubbery-enclosed pools. The damgah can be approached only at some points at the periphery, and to encircle the whole complex non-stop through the mud and thickets takes several hours or a day.

Thus spotting all birds is often impossible. Figure 2 thus only approximates the damgah, attempting to show the territorial areas and their relationship to each other, not the dimensions.

The main territories, A and B, are the most shared ones. The remote A, Ojoogel, shared by Trio, Duetto and Solo, is a scene of a ritual of changing foragers, as Trio alights from the air on Duetto's side with splattering of wings and trumpeting calls, driving Duetto off, the scene repeated in late afternoon the other way around. Often all three groups are seen feeding at different parts of A at the same time.

Territory B, Valikorut, is located centrally, and is shared by Duo and Grando, and in the beginning of the season by all others as well, but Grando dominates B and B/o in the outside fields.

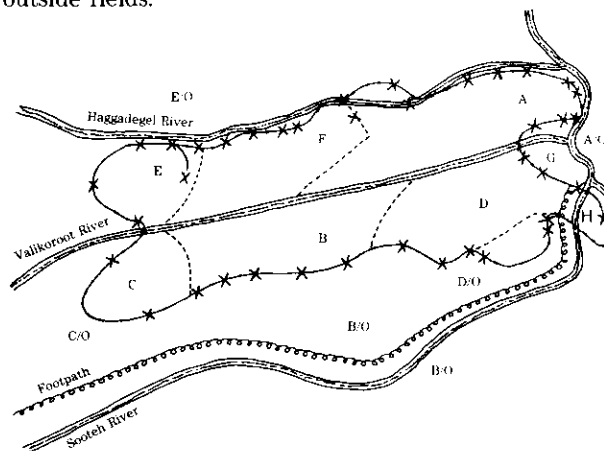


Figure 2. Territories in Damgah of Fereidookenar (X) trapping stations = damgahs.

A-H = Territories:	C - Ghela - west pocket	F - Haggadegel
A - Ojoogel	D - Gedayesh and Vahmi	G - Telajigel, also includes A/O
B - Valikoroot	E - Ghela - east pocket	H - Dustigel

Territory C, Ghela, and C/o, becomes in January and February the most convenient area to observe Duo, a rather bold pair, who are seen foraging near the approach to the road in C and C/o. Territory E and E/o is used by a group of three (most likely Grando) according to a trapper.

Area D, Gedayesh, serves as transients' relief with no dominating group, or perhaps Duetto whom I saw roosting there after being driven off their pad in A at 1730 hours one night. Roosting, then, also seemed to occur in the territories, as I observed Trio and Solo roosting all night in A (observed them there at night at 1900 hours and next morning at 0630 hours), as well as Duo in C, leaving Grando, though unobserved, also roosting in its own territory. These observations are in conflict with the trappers' stories that the cranes gather in A to roost at night.

The territories have, thus, become quite clearly definable, except for the overlap areas. The trend toward feeding in the outside fields increases toward the end of season as finding food inside the damgah has become harder, no doubt. But the feeding habits of the cranes are not so regular that one can depend on observing them at any par-

Groups	Territory										Total Sightings
	A	A/O	B	B/O	C	C/O	D	D/O	E	E/O	
Grando			3	12					1?		15
Trio	8			2				1		1?	11
Duo			2		5	3	3				13
Duetto	7						3				10
Solo	6	3									9

**Table 2.** Frequency of sightings for Siberian crane groups on territories at Fereidoonkenar, 15 November 1986 to 23 February 1987.

ticular time in a certain place. Table 2 summarizes the occupancy of various territories as outlined in Figure 2. Each group was observed in both mornings and afternoons for a total of 58 sightings in weekly visits to the damgah.

#### ECOLOGY OF THE WINTER HABITAT

Climatically a humid, temperate region with rainfall all year round, the Caspian littoral would have subtropical weather if not modified by the continental influence of the Alborz mountain range. The average winter temperature range during the night is 0-10°C, and 12-20°C during the day, with an occasional high of 24°C, while the summer high of 30°C and lows of 14-15°C are accompanied with high humidity (up to 90%). Phytogeographically, this Hyrcanian region was all under summer-green forests of Tertiary origin, of which now some relic stands remain; but most coastal areas have been cleared, mainly for rice cultivation. The high precipitation in winter floods the land, providing natural lakes for waterfowl, but the damgahs are artificial pools created by trappers by secluding sections of the flooded fields for their purpose of trapping the waterfowl. The fences and blinds in these damgahs are partially formed by trees from the original forests of hornbeam *Carpinus orientalis*, beech *Fagus orientalis*, ash *Fraxinus excelsior*, elm *Celtis* sp., maple *Acer laetum* and *A. insignia*, boxtree *Buxus sempervirens*. White willow *Salix alba* and alder *Alnus glutinosa* predominate in these damp conditions. The original forests are characterized by oaks *Quercus* spp., ironwood *Parrotia persica*, lime tree *Tilia rubra*, and the Caucasian wingnut *Pterocarya fraxinifolia*.

The vegetation inside and around the Fereidoonkenar Damgah has plant associations of the reed *Phragmites australis*, forming islands around which the Siberian cranes often feed and rest; embankments extending into the fields are dense with sedge *Cyperus longus*, in association with arrowhead *Sagittaria sagitifolia*, purple loosestrife *Lythrum salicarium*, buttercup *Ranunculus sceleratus*, and *Calomagrostis* sp. Vegetation growing in the inundated areas where the cranes were seen foraging included dominantly sedge *Cyperus* spp. Other plants in association were water plantain *Alisma plantago-aquatica*, nasturtium *Nasturtium officinalis*, hornwort *Ceratophyllum* sp., pondweed *Potamogeton nodosus*, and the bulbous *Arum maculatum*, as identified by botanists of the College of Natural Resources of the University of Mazandaran (Hassan

Abbassi) and of the Department of Environment of Iran (Borhan Riazi).

The Department ornithologist, Jamshid Mansouri, related seeing the Siberian crane foraging on culms of flowering rush *Butomus umbellatus* during his annual observations (Mansouri 1981).

The waterfowl in the damgah are dominated by mallards *Anas platyrhynchos*, teal *Anas crecca*, pintails *Anas acuta* and greylag geese *Anser anser* (very numerous the past season) with a few greater white-fronted geese *Anser albifrons*, besides great egrets, grey herons *Ardea cinerea*, and numerous cormorants *Phalacrocorax carbo*. In fall and early spring, many migrant waders also stop here, such as black-winged stilts *Himantopus himantopus*, greenshanks *Tringa nebularia*, black-tailed godwits *Limosa limosa*, common snipes *Gallinago gallinago*, besides the thousands of northern lapwings *Vanellus vanellus* which winter in the damgah as well. Sometimes a whooper swan *Cygnus cygnus* or a white pelican *Pelecanus onocrotalus* may be seen, and in the surrounding rivers the kingfisher *Alcedo atthis*, various reed warblers, etc. Many common buzzards *Buteo buteo*, black kites *Milvus migrans* and the white-tailed eagle *Haliaeetus albicilla* provide regular disturbance among the waterfowl without perturbing the cranes, however. Among mammals, only jackals *Canis aureus* are prevalent and the shrew *Crocidura leucodon* may be seen darting in and out of the rotting logs in the bogs.

#### FEEDING ECOLOGY OF THE SIBERIAN CRANE

Close observation of the cranes in the damgah is made difficult due to problems of access, which is often rudely controlled by the trappers. Enough staggered observation periods, however, were accumulated in order to cover the whole day's activity patterns of more than one group.

Foraging was an all-day activity, with more intense periods in early morning from 0630 to 1000 hours and in late afternoon from 1500 to 1730. The Siberian cranes expend much energy in probing for their food, the tubers of plants, apparently mostly sedge *Cyperus* spp. In submerged feeding grounds and at long observation distances, however, the exact morsels of food they consumed were almost impossible to distinguish. There was a rhythm in the process of probing, each 8-22 pokes into the mud seemingly producing a food morsel which was swallowed, averaging perhaps 3/min at high feeding efficiency. During probing periods, the bird would look up every minute

or two to watch, but much less often in the safety inside the damgah than outside. The male seemed to do more of the watching, while juveniles, with lower feeding efficiency, watched the least often. Sometimes the cranes would go poking into the drier banks of the ricefields which were green with *Cyperus longus* in many stretches.

While rest periods were usually short in mid mornings, with sporadic preening, walking, watching (i.e., the birds looked idle), the afternoon period between 1300 and 1500 hours usually included a thorough preening of 30 min by each bird, in turns, until another intense feeding bout commenced in the late afternoon until 1730-1800 (sundown).

Perhaps the most visible vegetation at the feeding sites was sedge *Cyperus* sp. (not *C. longus*) among wilted stalks of rice; by the end of February, however, there were many sprouting bulbs. Complete analysis of vegetation can only be made later in the season, but the picture is then distorted by the fields being plowed under for rice and treated with fertilizers (urea and ammonium phosphates) and herbicides [(2,4 dichloro 5(1-methylethoxy)phenyl-5-(1,1-dimethylethyl)-1, 3,4-oxadiasol-2(3H)], the *Cyperus* being considered a bad weed; it is also known to be resistant to herbicides (Rao and Dubey 1980). Water levels varied, but mostly the cranes were standing in 5 - 20 cm of water, seldom requiring immersion of the head, only the beak. The water is neutral with pH close to 7, not saline (conductivity at 0.5 mg/l [7.9 micro  $\mu$  ]).

#### OTHER BEHAVIORS

##### Begging and Display

The Siberian cranes are very discrete in their interactions,

although there exists an obvious tension of awareness between members of the group. Once only did I observe a juvenile begging from its mother who was digging in the banks, quite hard work; the feeding by the mother lasted about 20 min, the juvenile standing in the posture described by Sauey (1985). Only twice did I observe a male of Trio display a sequence of the "unison call" (Sauey 1985), not directed to his partner but towards Duetto 50 m away. A few times I heard calls, which must have been accompanied by displays I could not see.

##### Antagonistic Behavior

This was already described in territorial behavior, only exhibited at the beginning of the season, and by Trio and Duetto in territory A which they shared.

#### CURRENT SAFETY AND FUTURE SECURITY OF THIS POPULATION

The damgah is not protected, except by the trappers themselves, whose activities with net-traps are actually illegal. The safety of the Siberian cranes thus lies in the hands of these farmer-trappers. The cranes have gone so long unmolested and so long protected both by the furtive atmosphere prevailing around the damgah and by the preoccupation of the trappers with ducks, that we may continue to rely on this innate protection. International societies under today's conditions in Iran attract little positive interest, nor does the possibility of official involvement of the Department of Environment. I do hope that cooperation between the farmer-trappers and scientists will one day be possible on behalf of the Siberian crane.

#### ACKNOWLEDGMENTS

Botanists of the College of Natural Resources of the University of Mazandaran and of the Department of the Environment of Iran, Mr. Hassan Abbassi and Mr. Borhan Riazi, respectively, cooperated in identifying the flora.

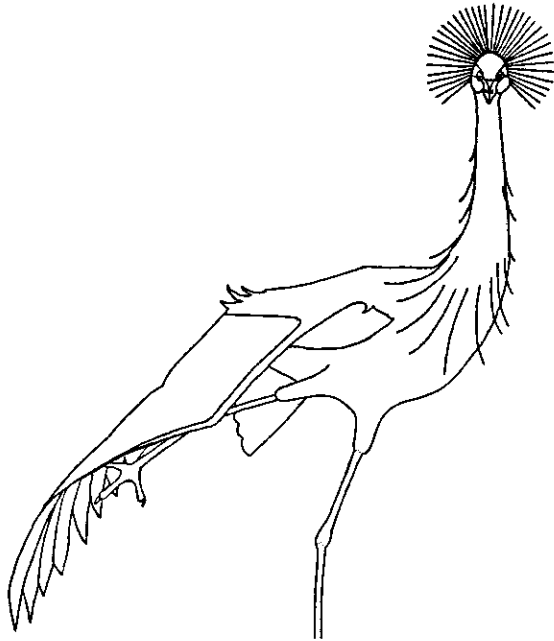
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CHAPTER 11  
AFRICA







## RECENT RESEARCH AND CONSERVATION ACTIVITIES WITH CRANES IN AFRICA

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### ABSTRACT

This paper reports research and conservation activities with cranes in Africa from April 1985 through March 1987. Included here are: activities of the Working Group on African Cranes, Kenya Working Group on Cranes, Eastern Africa Working Group on Crowned Cranes; a planned survey of wattled cranes *Bugeranus carunculata* in Botswana; a survey of grey crowned cranes *Balearica regulorum* by the Wildlife Clubs of Kenya and plans for other studies of cranes in Kenya; estimates of black crowned crane *Balearica pavonina* numbers in the Inner Niger Delta of Mali and suggested reasons for their possible decline; discovery of a possibly important post-breeding dispersal area of wattled cranes in northeast Namibia; numbers of cranes in Niger; renewed interest in conservation of cranes in Nigeria; a 1985-1986 census of wattled and blue cranes *Anthropoides paradisea* in South Africa; studies on the ecology and conservation status of grey crowned cranes in Uganda; plans for studies of cranes in Zambia; and a proposed second wattled crane census in Zimbabwe.

### INTRODUCTION

In recent years there has been a growing interest in the biology and conservation of cranes and their habitats in Africa. In the 1970s a crane study group was formed in Southern Africa (Day 1980). In 1983, at the International Crane Workshop held in Bharatpur, India, the Working Group on African Cranes (WGAC) was established to stimulate studies on cranes and their conservation in all nations in Africa (Archibald 1985). The latter group met in Francistown, Botswana in 1985 and at Kingston and Ottawa, Canada in 1986; since 1986, WGAC has had its own publication, *The Crowned Crane*. In 1986 the Kenya Working Group on Cranes and the Eastern African Working Group on Crowned Cranes were established to conduct research on crowned cranes and their wetland habitats, to promote conservation of these cranes and their wetlands, and to monitor trade of these cranes and development projects that affect wetlands (Gichuki and Muringo 1986; Muringo and Gichuki 1986).

Several investigations on cranes were initiated in the 1970s especially in central and southern Africa, and in the early 1980s in other regions of Africa; these investigations through 1984 are reviewed by Urban (1987 and in press). Our paper reports research and conservation activities with cranes in Africa from April 1985 through March 1987.

### RECENT ACTIVITIES

#### Botswana

Ralph Bousfield has studied the distribution and breeding status of the wattled crane in the Okavango Swamp. Undertaken over several months and financed by Endangered Wildlife Trust (South Africa) and International Crane Foundation (ICF), his study showed that about 200 pairs of wattled cranes are in the Okavango area. Bousfield plans future aerial surveys over the Okavango, Linyanti and Chobe areas and a color-marking program. The Botswana Wildlife and National Parks has been invited to participate in ICF's intern and foreign fellow program. A request for field records of cranes appeared in the Botswana Bird Club's *The Babbler* (Urban 1985).

#### Kenya

The recent formation of the Kenya Working Group on Cranes has stimulated much activity in Kenya. In August 1985 the Kenya Wildlife Clubs, under the leadership of Nathaniel arap Chumo and Mannoah Kilach, published a questionnaire in the Clubs' magazine, *Komba*, requesting information on status, abundance, time of occurrence and nesting of the grey crowned crane and status of local wetlands used by cranes. Data from 430 responses to this

questionnaire indicate that these cranes are widely distributed in Kenya; that their main breeding areas are in potentially important agricultural land in central and western Kenya; that wetlands in Kenya are rapidly shrinking due to clearing, burning and overgrazing by livestock; that some cranes have failed to breed in apparently suitable habitats because of harassment by local people; and that the local people do not consider the conservation status of birds, including cranes, as important as that of mammals. In addition, this survey indicated that numbers of grey crowned cranes in Kenya have declined in recent years. There are plans to enlarge this survey into an annual day-long count when all Wildlife Clubs will record cranes in their respective areas of Kenya.

Other surveys of crowned cranes in Kenya have been carried out. For example, Cecilia Muringo (alias C.M. Gichuki) and one of us (Nathan Gichuki) conducted crane surveys in Amboseli, Naivasha, Saiwa Swamp, Lake Ol Bolosat and Nairobi National Park; some results of this survey and information on relationships between habitats and flock characteristics in foraging crowned cranes from Saiwa Swamp and Lake Ol Bolosat were reported to the 1987 International Crane Workshops, held in Qiqihar (Gichuki and Gichuki this proceedings). C. Muringo gathered some data on cranes in Kenya via the *Avifauna*, the publication of the Bird Room, National Museums of Kenya. In March 1986, L. Eccleston counted 966 crowned cranes in six localities in Kenya's Kisli District; members of the Agricultural Department counted 863 in 1963 (D. Turner pers. comm.). These data indicate that cranes still flourish in an area where human population has grown from 650 individuals/mi<sup>2</sup> in 1963 to 900/mi<sup>2</sup> in 1986.

Nathan Gichuki plans to carry out a study entitled, "The Biology and Conservation of Crowned Cranes in Kenya," in partial fulfillment of the requirements of the Ph.D. at the University of Nairobi. This study will encompass a program to color band these cranes to determine specific behaviors of individuals and their movements.

In the last few years concern has increased about the large number of crowned cranes, especially young birds, that have been exported from Kenya. For example, in 1986 about 400 individuals were exported from Nairobi largely to the Netherlands (G. Cunningham-van Someren pers. comm.).

C. Muringo and Nathan Gichuki (in press) also reported on the activities of the WGAC to the International Symposium of African Wildlife, Kampala, Uganda, describing the history of WGAC and calling for support of the Eastern African Working Group which includes Rwanda, Burundi, Uganda, Ethiopia, Sudan, Tanzania and Kenya.

#### Mali

Skinner (1988) estimated that in 1985-1986 there were 1000 to 2400 black crowned cranes in 20,000 km<sup>2</sup> of the Inner Niger Delta flood plain and suggested that the calculated estimates of 3000 and 6000 for 50,000 km<sup>2</sup> of the Delta, as reported by Urban (in press), may be slightly high. Skinner also reported that the rains of 1985 and 1986 resulted in more flood-fed vegetation than in 1984,

and breeding was "good" (according to local fishermen). This state contrasts with the situation in 1984, when we saw no young cranes. Skinner pointed to factors that may be affecting crane population in the Inner Delta, including: 1) amount of flooding and its influence on availability of breeding habitats; 2) destruction of breeding habitat by a large cattle population and by rice farming; 3) capture by fishermen of young cranes to be sold, held as pets, or used for "traditional medicines;" and 4) the effect that the long and hot, dry season may have in reducing delta habitats that cranes occupy in the non-breeding season. He encouraged long-term studies to determine: 1) how stable the Inner Delta populations are from year to year, and 2) to learn if cranes are resident or migratory in the area. If migratory, do they migrate elsewhere in the non-breeding season every year, or only during periods of extreme drought?

#### Namibia

C. Hines (pers. comm.) has studied the occurrence, feeding ecology and population structure of wattled cranes in Bushmanland (about 20-21°S, 20-21°E) since 1984. He estimates that 80 to 100 birds (possibly over 150, C. Brown pers. comm.) occur there from mid December to April or May, when they depart. This area may be an important post-breeding dispersal location for wattled cranes since they are often seen there in groups of three (possibly parents and young of the year). C. Brown (pers. comm.) reported that the area will be farmed more intensively, to the detriment of the cranes. Hines also reported that the wattled crane population along the Kavango River has been greatly reduced in recent years, probably due to habitat destruction and disturbance along the river's flood plain. Brown plans to carry out a program to mark the blue crane population in Etosha National Park.

#### Niger

P. Giraudoux (pers. comm.), as part of his study of the avifauna of Niger (based on published and 3,000 to 4,000 unpublished records), suggested the black crowned crane in Niger occurs largely along the Niger River, mainly at Tillabery on the Mali border and also in the vicinity of Komadougou Yobe. He offers several reports from southwest Niger (about 12°N, 3°E; two birds on 17 April 1979, a few birds in January 1980 including a large chick in a market, and one bird each in June and September 1984); from western Niger along the Niger River (several groups of 10 in 1978, 86 birds on 12 September 1984, and 11 birds in 1985); and from southeast Niger and the Lake Chad area (several birds each in July and August 1975 and in December 1977).

#### Nigeria

Several individuals are concerned about the status of the black crowned crane in this nation. A.U. Ezealor of Ahmadu Bello University is cooperating with ICF to develop a public education program, while Hadi Mustafa

of the Ministry of Agriculture and Natural Resources hopes to send three of his staff to ICF for training in crane conservation techniques. Philip Hall (pers. comm.), also of this Ministry, reports that the population of black crowned cranes has continued to decline in recent years in Nigeria. For example, in 1986-1987 he saw only a few black crowned cranes, including once a flock of about 8 to 10 birds in Borno State but none in neighboring Kano State. He suggests that the major factor responsible for the decline in the crane population in recent years may be the marked reduction in the wetlands of the area.

#### Rwanda

There are plans to study the population and recruitment of grey crowned cranes in Akagera National Park in the next year or so (J.F. Vande weghe pers. comm.).

#### South Africa

Several activities involving cranes in this nation have taken place in the last few years. A census to count wattled cranes, blue cranes and grey crowned cranes was conducted in November and December 1985, and in January and July 1986. Included in the census were casual sightings, road censusing, detailed crane counts over weekends, and aerial counting. G. Holtshausen and J. Ledger were in charge of the census which was sponsored by Southern African Ornithological Society, Endangered Wildlife Trust, South Africa Nature Foundation, Wildlife Society, and Lagamed (Holtshausen and Ledger 1985). Data are now being analyzed and results should be forthcoming soon (John Ledger and G. Holtshausen per. comm.).

In addition, Johnson and Barnes (1986) carried out a census of blue, grey crowned and wattled cranes in Natal, counting them monthly from January 1980 to December 1982. They found that numbers of blue cranes (aerial counts in 1982 found 1130 birds) and grey crowned cranes (aerial counts in 1982 found 945 birds) were roughly equal although their distributions were different. Thus, nearly all blue cranes were recorded in northwest Natal whereas grey crowned cranes were more evenly distributed with substantial concentrations in the southwest. Wattled cranes were much rarer (aerial counts in 1982 found 174) and had a more restricted distribution. Johnson and Barnes also estimated that approximately half of all wetlands in the Natal midlands disappeared between 1950 and 1980 and expressed concern that if wetland loss is not halted, the cranes of Natal could become extinct.

Other activities include: 1) the cooperative project of the Endangered Wildlife Trust, Natal Parks Board, Transvaal Division of Nature Conservation, Southern African Ornithological Society and South African Nature Foundation to protect wattled cranes (J. Ledger pers. comm.); 2) Natal Parks Board projects to develop a crane and wetland interpretation center at Himeville, Natal, and to rehabilitate the Mvoti Vei (northeast of Pietermaritzburg) with the result that wattled cranes are re-inhabiting and possibly nesting here (G. Hughes pers. comm.); 3) a color-marking program of pre-fledged wattled cranes to deter-

mine their disposal rate (David Roberts and George Archibald pers. comm.); 4) the monitoring of nesting wattled cranes in Natal and Transvaal by D. Johnson and Warwick Tarboton; 5) development of crane expertise via ICF internships by D. Roberts and Robert Filmer; and 6) the proposed re-introduction of wattled cranes into wetlands in the northeastern Cape by the Cape Province's Department of Nature and Environment (J.A. van Zyl pers. comm.).

Recent encouraging news for the survival of wattled cranes in South Africa was a December 1986 report (R. Broode pers. comm.) that wattled cranes have nested in a reflooded vlei in the eastern region of Cape Province. Discouraging crane news in South Africa, however, includes the August 1986 report that 180 of 200 grey crowned cranes at the breeding site at Xaxo along the Transkei Wild Coast were killed by a local person using poison-soaked maize (George Archibald pers. comm.).

#### Sudan

As part of White Stork project sponsored by the World Wildlife Fund/International Council for Bird Preservation in Sudan, H. Shulz and W. Kühle recorded their observations from 12 September to 19 October 1986 on common cranes *Grus grus* and demoiselle cranes *Anthropoides virgo* between 12° and 20°N latitude in Khartoum, Gezira, Kassala and Blue Nile provinces, especially associated with the Blue and White Niles and Atbara, Dinder and Rahad Rivers (Kühle 1986). They reported that: 1) local farmers look at cranes as pest controllers; 2) the sand banks of Blue Nile are the preferred resting places of cranes; 3) cranes arrive in "large" numbers in November; 4) cranes can be hunted legally; 5) local people catch cranes with a zafaroq (a type of boomerang), guns, snares, and nets, and sell them in markets where they are highly prized as food; 6) presumably several thousand cranes are killed annually; 7) spraying with pesticides appears to have a major effect on cranes; 8) research programs are needed, especially to determine the effect of pesticides on cranes; and 9) a major educational campaign is needed to protect cranes in Sudan.

#### Uganda

Recent studies on cranes in this nation include Paul Mafabi's investigation of the ecology and conservation status of the grey crowned cranes. Results suggest this crane may undergo a major decline in the next five years because its breeding areas are being used for rice cultivation. (Mafabi this proceedings). As part of a two-year study of the grey crowned cranes in the swamps of eastern Uganda, Mafabi and Pomeroy (1988) have learned that local people keep young cranes as pets; they hope to learn how this practice along with commercial trade affect crane populations in Uganda. In addition, records of cranes have been kept since 1986 in Queen Elizabeth National Park (P. Kasoma pers. comm.) and in southwestern Uganda. In the latter area cranes appear to be fairly common despite one of the densest human

populations in Africa and the large scale drainage of swamps (T. Butynski pers. comm.).

#### Tanzania

David Moyer (pers. comm.) has prepared a project proposal to determine the distribution and status of wetlands and wattled cranes in Tanzania and the basic biology of the cranes. This project will be initiated as soon as it can be funded.

#### Zambia

Mr. V. Katankwa (pers. comm.) of the Livingstone Museum has recently expressed interest (February 1987) in censusing wattled and grey crowned cranes in his nation. Mr. M. Sichilongo of the Wildlife Conservation Society of Zambia (G. Archibald pers. comm.) has been encouraged to heighten the interest of local people in the cranes of Zambia. Records of cranes in Zambia are reported in the *Newsletter* of the Zambian Ornithological Society (D. Aspinwall pers. comm.), and it is hoped that censusing of wattled and grey crowned cranes will be included in the Wetland Project (Kafue-Bangweula) under the leadership of Dr. Harry Chabwela of Zambia's National Parks and Wildlife Service. The proposed project by Dr. G. Howard of the University of Zambia and one of us (E. Urban) to do a detailed long-term study of the biology of the wattled cranes on the Kafue Flats is in the planning stage.

#### Zimbabwe

Mundy (1987) has summarized what is known about the status and ecology of the wattled crane in this nation. He has suggested that determination be made of population structure, size of the areas occupied by pairs and their young, and habitat preferences of these cranes before additional surveys of wattled cranes are performed. Another recent activity is the 1987 ground and aerial census of wattled cranes by the Wildlife Trust of Zimbabwe. The Trust is now analyzing the results of this census and in addition has plans to establish breeding units of wattled cranes in captivity, with the goal of eventual release of birds into the wild (C. Tracey pers. comm.).

#### FUTURE PLANS

The working session of the WGAC at the 1987 International Crane Workshop, held in Qiqihar, began preparation of a five-year crane action plan for Africa. When completed, this report will include: comments on the cranes' classification, status, distribution, biology, and reasons for decline; strategies and priorities for crane conservation; critical habitats; and recommendations for conservation action. This report will become part of the five-year worldwide crane action plan to be compiled by ICF and published by the International Union for Conservation of Nature and Natural Resources.

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# RELATIONSHIPS BETWEEN HABITAT SELECTION AND FLOCK CHARACTERISTICS IN FORAGING GREY CROWNED CRANES *BALEARICA REGULORUM* IN KENYA

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## ABSTRACT

Grey crowned cranes *Balearica regulorum* breed in marshes but feed in a wide range of habitats, often away from the breeding sites. The size and composition of foraging flocks are governed by a composite of competition factors. Habitat characteristics, however, may have profound effects on flocking patterns of cranes. The influence of habitat on the flocking behavior of cranes was investigated in two upland swamps in Kenya. Between August and December 1986, we determined habitat availability, patterns in habitat use, and characteristics of foraging flocks of cranes at Saiwa Swamp and Lake Ol Bolossat. The results obtained are presented and discussed.

## INTRODUCTION

Foraging behavior and its relationship to habitat choice and food resource utilization in animals have received considerable theoretical attention and research effort during the last decade (Ellis et al. 1976; Pyke et al. 1977; Krebs 1978). One possible mechanism for optimizing foraging is altering the group sizes in response to temporary or permanent changes in habitat characteristics or abundance in food resources. Crowned cranes forage for food in a wide range of terrestrial and semi-aquatic habitats. They forage singly, in pairs, family groups, and often in flocks. The cranes utilize both natural and semi-natural habitats among human settlement in central and western Kenya.

In this paper, we examine the group sizes and behavior of foraging cranes in relation to habitat characteristics in two upland wetlands in Kenya. The object of the study was to determine whether cranes alter their foraging behavior in response to habitat type (substrate) and to temporary human-induced changes in their foraging habitats.

## STUDY SITES

Two wetlands in central and western Kenya were selected for this study because they are potentially important for conservation of cranes. At an altitude of 2,340 m, Lake Ol Bolossat (36°26'E, 00°09'S) is 90 km<sup>2</sup> and lies in a fault valley. On the eastern side of the lake there is a 30 km long escarpment at the base of which small streams draining into the lake originate. The natural vegetation of the lake basin consists of marshes, short pasture grasses, and sedges. There are also cultivated fields on eastern and western sides of the lake.

Saiwa Swamp National Park (35°07'E, 01°14'N) lies at an altitude of 2,150 m. A stream originating from the Cherangani Hills flows through the swamp and joins the Nzoia River which drains into Lake Victoria. About 65% of the park consists of marshes, which are bound by a ring of native forest. Adjacent to the forest are tall grasses with scattered shrubs, short pasture grasses, and then cultivated fields. The park is only 3.0 km<sup>2</sup> and its primary purpose is to provide refuge to the rare swamp-dwelling antelope, Sitatunga *Tragelaphus spekei*.

At both Saiwa Park and Lake Ol Bolossat, the annual rainfall exceeds 1,000 mm with 60% of it falling during the period between March and May. Fertile agricultural land surrounds the two sites, the principal agricultural activities being food grain production and livestock keeping.

## METHODS

The results presented in this paper are for the period between 3 August and 30 December 1986. They are part of a three-year study which was still in progress at the time of reporting.

Two transects, each 500 m long and oriented perpendicular to the edges of the marshes, were established at Lake Ol Bolossat and two more at Saiwa Park, for the purpose of sampling the vegetation. The transects extended from the lower limits of the emergent vegetation to the upper limits where cultivation started. The main habitats traversed by the transects were noted and the dominant plant taxa present identified.

The changes in the foraging habits of cranes at different times of the day were studied by recording the number of birds foraging in 50 x 50 m blocks in each of the principal

habitats traversed by the vegetation transects. Observations were made at hourly intervals from 0600 to 1800 by four persons walking or riding at the back of an open vehicle, each person with a pair of binoculars. Eighty person-days spread over the study duration of five months were spent at each of the study sites.

Records were made of birds foraging alone and birds foraging in flocks; within flocks, subgroups were often evident. For the purposes of data analysis, a group was defined as two or more cranes that were foraging together and that maintained nearest neighbor distances of less than 6 m on average. Those distances were estimated between individuals of 14 pairs at each study site and in 12 subgroups of 3 or more birds at each site. The nearest neighbor distances in the subgroups were used to compute the statistic *R*, used for measuring the amount of aggregation in birds (Clark and Evans 1954).

The changes in the sizes of foraging groups due to emigration and immigration were assessed at 30-min intervals from the time the group was first sighted to the time the group dispersed. If a group failed to disband, the observations were terminated after ten 30-min sessions. Observations and counts were also made of cranes arriving and departing at a frequently used site within the study area. These counts and observations of cranes were made once a week for ten non-consecutive weeks at each of the two main study areas. Statistical tests were obtained from a wide range of references but mainly from Siegel (1956), Sokal and Rohlf (1969), and Zar (1984).

## RESULTS

### Habitats

Major habitat types potentially available to cranes were identified at Lake Ol Bolossat and Saiwa Park (Table 1). Except for the lake marshes at Lake Ol Bolossat and native forest at the periphery of the swamps at Saiwa Park, the rest of the habitats were common to both study sites. In terms of land area, however, there were more wet habitats at Lake Ol Bolossat (52.4%) than at Saiwa Park (19.1%). Surface elevation changes within the transects at Lake Ol Bolossat gave slopes of 0.64 m/km while those at Saiwa Park gave slopes of 0.78 m/km.

Habitats	Lake Ol Bolossat	Saiwa Park
Lake marshes	43.0	-
Stream marshes	9.4	19.1
Pasture grasses	22.6	24.9
Wooded tall grasses	10.0	11.0
Forest	-	9.2
Cultivated fields	15.0	35.8
Total	100.0	100.0

**Table 1.** The percentage distribution of the main habitats utilized by cranes at Lake Ol Bolossat and Saiwa Park, Kenya. Based on two 500-metre transects at each site.

The plant species that were abundant and widely distributed within the lake marshes at Ol Bolossat were *Phalaris arudinacea*, *Cyperus digitatus*, *Cirsium vulgare*,

and *Cyperus papyrus*. In many sites the plant species occurred together, with the dominant species varying from site to site within the lake basin. The stream marshes were comparatively small and dominated by reeds of *Cyperus* spp., often mixed with grasses of *Phalaris* spp. The short grass sections, usually flooded when the lake water level rises, were covered by pasture grasses such as *Pennisetum clandestinum*, *Chloris virgata*, and legumes, particularly *Trifolium semipilosum*. The upper parts of the basin were covered by wooded tall grasses such as *Themeda triandra*, *Pennisetum sphaecelata*, and *Sporobolus* spp. Tall grass with scattered trees bordered the lower limits of the cultivated areas where the principal crop grown was maize *Zea mais* intercropped with legumes.

The principal swamp vegetation at Saiwa Park consists of reeds *Cyperus latifolius*, bulrushes *Typha latifolius*, and tall swamp grasses such as *Echinochloa pyramidalis*. Amongst these species, a dicotyledonous forest herb *Plectranthus edulis* has established itself and is the dominant species in some parts of the swamp. Upland sedges *Macriscus* spp. occupy the shallow parts of the swamp, especially where underground water emerges.

As shown in Table 1, 36% of the 50 m transects traversed through cultivated areas at Saiwa Park, and only 19% of it passed through the swamp. The stream that passes through the swamp is relieved of its silt load. The silt is deposited in the swamp, choking some plants but encouraging regrowth when the water level subsides. Among the conspicuous trees in the periphery of the swamp are *Syzygium guiniense*, *Croton macrostachyus*, *Ficus capensis*, and *Acacia abyssinica*. Outside the forest, tall grasses such as *Hypparhenia collina* grow amongst short trees and shrubs of *Acacia hockii* and *Techlea nobilis*. The short grass sections are dominated by pasture grasses, especially *Pennisetum clandestinum*. In cultivated areas, weed plants such as *Sataria verticillata* and *Amaranthus hybridus* occurred in patches. The principal crops grown in the surrounding small-scale farms were maize, wheat *Triticum vulgare*, and sunflower *Helianthus annuus*.

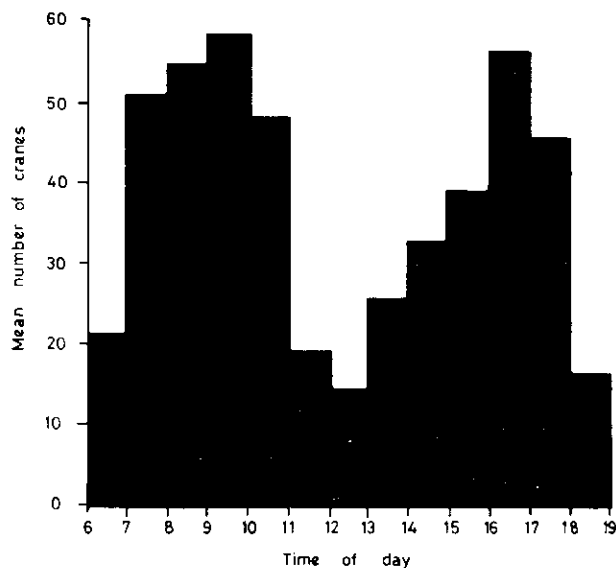
### Diurnal Foraging Pattern

At both Lake Ol Bolossat and Saiwa Park, there was no marked daily pattern of activity. Cranes foraged for food nearly all day (Figure 1). The feeding activities of cranes started 15 min before 0600 and continued with a short mid-day break until 1830.

In dry substrates, there were always more cranes feeding at 0830 and 1730 than 1230 ( $P < 0.05$  in both comparisons,  $n = 14$ , Mann-Whitney one-tailed U-Test). At midday, feeding activities in dry substrates were suspended for a duration of 1.5 - 2.5 hours, when cranes moved to water-drinking sites in the river marshes, ponds, and man-made dams. The cranes fed intermittently as they drank water, and continued feeding in wet substrates after drinking. At about 1430, the birds moved to feed in dry substrates where they remained until 1830, occasionally up to 1930 when near an established roost site.

Thus, cranes utilized wet and dry substrates as feeding sites every day. At both Saiwa Park and Lake Ol Bolossat,





**Figure 1.** Changes in foraging activity of cranes at different times of the day: number of cranes foraging at hourly intervals at Lake Ol Bolossat, Kenya.

there were temporary habitats for which cranes showed apparent preference. Such habitats included post-harvest crop stubbles, freshly ploughed fields, burnt-up areas, livestock-feeding lots, and patches of reclaimed swampland. Availability of these temporary habitats had no effect on the daily foraging pattern. At Saiwa Park and Lake Ol Bolossat, no significant difference was detected between the daily number of cranes foraging in wet and dry substrates before and after noon ( $X^2 = 0.12$ , d.f. = 1,  $P < 0.01$ ). As indicated in Table 2, however, cranes tended to use dry substrates more often than wet substrates.

	Number of cranes and substrate type		
	Wet type	Dry type	Total
Before noon	134	161	295
After noon	121	153	274

**Table 2.** Distribution of cranes according to time of day. Data pooled for Lake Ol Bolossat and Saiwa Park, Kenya.

### Social Behavior

Cranes foraged for food in flocks, sometimes in pairs, but only temporarily as single birds. Adult and subadult birds foraged together. The movements of the individuals were coordinated so that the birds kept together as they foraged. Within the flock, however, there were subgroups whose individuals maintained close vocal and visual contact. The subgroups consisted of pairs or of family groups, the latter including a pair with subadult birds.

On departure from a feeding or drinking site, a group would fly for a short distance and then start dispersing. Some birds would land, others would fly back to the site of origin and join another group, presumably parents or partners. Other birds would continue flying, with young birds flying slightly behind the adult leaders. These changes

in flock composition were temporary since the birds regrouped within 1-2 hours of departure.

On landing at a foraging site, the individual cranes formed subgroups. For 12 such subgroups of more than 3 birds each, R values (see METHODS) ranged from 0.19 to 0.68. The mean nearest neighbor distance in the subgroups of cranes at Lake Ol Bolossat was  $4.1 \pm 0.3$  m and for a similar number of subgroups at Saiwa Park was  $3.4 \pm 0.2$  m. Thus, the subgroups were more spaced out at Lake Ol Bolossat than at Saiwa Park. The mean nearest neighbor distance between members of 14 pairs at Lake Ol Bolossat was  $2.4 \pm 0.7$  m whilst at Saiwa Park it was  $2.8 \pm 0.5$  m. The members of subgroups maintained close vocal and visual contact with each other when foraging.

### Habitat Utilization by Crane Groups

Of 5739 cranes recorded in this study, 64% were at Lake Ol Bolossat and 36% at Saiwa Park (Table 3). Identical proportions of the crane populations at Lake Ol Bolossat and at Saiwa Park utilized wet habitats, 26.1% and 26.3% respectively. Pasture fields, marshes, and cultivation areas supported nearly 90% of the total population. Other habitats, considered individually, were of secondary importance to cranes.

Habitats	Number and % distribution of cranes			
	Lake Ol Bolossat		Saiwa Park	
	Number <sup>a</sup>	%	Number <sup>a</sup>	%
Lake marshes	82	2.2	-	-
Stream marshes	878	23.9	543	26.2
Pasture grasses	2097	57.1	852	41.2
Wooded tall grasses	252	6.9	192	9.3
Forest	-	-	25	1.2
Cultivated fields	362	9.9	456	22.1
Total	3671	100.0	2068	100.0

**Table 3.** Distribution of cranes in wet and dry habitats at Lake Ol Bolossat and Saiwa Park, Kenya.

<sup>a</sup>Numbers represent totals of our different counts of the birds, and thus are much greater than the actual crane populations present during the study period.

More cranes foraged in pasture fields, often together with cattle and sheep, at Lake Ol Bolossat and at Saiwa Park than in any other habitat (Table 3). The fields consisted of natural pasture grasses and often of sown fodder legumes. At Lake Ol Bolossat, significantly greater numbers of cranes foraged in stream marshes than in lake marshes ( $X^2 = 9.6$ , d.f. = 1,  $P < 0.01$ ).

The preference of cranes for stream marshes at the lake was reflected by their densities: 12 cranes/ha in stream marshes and 7 cranes/ha in lake marshes (Median Test,  $X^2 = 8.1$ , d.f. = 1,  $P < 0.01$ ). Several factors, including an abundant food supply, availability of non-saline drinking water, and low livestock densities (hence reduced disturbance) account for the preference of cranes for stream marshes. Both lake and stream marshes, however, were occupied by nesting pairs of cranes during the breeding periods.

The group sizes of cranes ranged from 2 to 130 birds at Lake Ol Bolossat and from 2 to 50 birds at Saiwa Park. The

mean group sizes for the two sites were 15.4 and 14.2 birds respectively (Table 4). Larger groups were found in pasture fields and in the cultivated areas where ample waste grain seeds were abundant. Only 35% (65/188) of the crane groups at Lake Ol Bolossat and 20% (23/117) of those at Saiwa Park were found in wet substrates. Therefore most of the crane groups, especially the larger ones, foraged in dry habitats.

Habitats	Lake Ol Bolossat		Saiwa Park	
	Mean number of groups	Mean group size <sup>a</sup>	Mean number of groups	Mean group size <sup>a</sup>
Lake marshes	17	4.8	-	-
Stream marshes	48	18.3	23	19.7
Pasture grasses	69	30.4	40	21.3
Wooded tall grasses	30	8.4	19	10.1
Forest	-	-	7	3.6
Cultivated field	24	15.1	28	16.3
Mean	37.6	15.4	23.5	14.2

**Table 4.** The distribution and size of crane groups in different habitats at Lake Ol Bolossat and Saiwa Park, Kenya.

<sup>a</sup>Each group size is a mean of eight observations.

During the five months of study, significant differences were found (Table 5) between the group sizes of cranes utilizing wet and dry substrates ( $X^2 = 11.8$ , d.f. = 8,  $P < 0.05$ ; data pooled for Lake Ol Bolossat and Saiwa Park). For instance, at Lake Ol Bolossat more single cranes and pairs were found foraging in wet habitats (marshes) than in dry habitats ( $X^2 = 9.8$ , d.f. = 3,  $P < 0.05$ ). At Saiwa Park, however, there was no consistent difference in the size of crane groups distributed over wet and dry habitats. In the park, a few crane groups foraged for food on the forest floor, an unusual habitat for cranes.

Month	Mean number of cranes	
	Wet substrate	Dry substrate
August	8.4	13.2
September	13.2	19.3
October	17.1	46.2
November	12.0	42.3
December	7.4	65.8

**Table 5.** The mean size of crane groups found in wet and dry substrates during the period August - December 1986. Data pooled for Lake Ol Bolossat and Saiwa Park, Kenya.

Some crane flocks utilized particular foraging sites for several consecutive days and sometimes weeks. The cranes would leave the site in small subgroups in the evening and regroup in the morning the next day. In the farmland around Saiwa Park, a flock of 44 cranes foraged in one field containing post-harvest wheat stubble every day for nine weeks. During the period, the flock size changed by only 4%. Another group of 56 cranes foraging in a similar habitat at Lake Ol Bolossat used one field for 11 weeks and its size changed by only 7%. At the latter site, a high correlation (Spearman Rank Correlation  $r = 8.81$ ,  $n = 44$ ,  $P < 0.01$ ) was found between the sizes of subgroups departing from a field

(in December 1986) and those arriving at a water-drinking site (stream marsh) 4.8 km away. Thus, a flock of cranes may remain intact for a considerable period of time despite the temporary changes that may occur within it.

## DISCUSSION

The populations of cranes studied at Lake Ol Bolossat and Saiwa Park were evidently resident. Pomeroy (1987) noted that in East Africa, crowned cranes make localized movements that are often confined to particular home ranges. The populations in the present study made local movements to foraging sites outside the study sites but nested and roosted within the study sites.

Crowned cranes are omnivorous. In Uganda, Pomeroy (1980) found that they eat arthropods, annelids, crustaceans, gastropods and their shells, and other small animal food items. In this study, they were also found to eat shrews and small rodents. Their plant food consisted of seeds, leaves, and bulbs dug out of the ground. Thus, the food of cranes was diverse though the available quantities were not directly assessable from the data obtained. The diversity of food consumed was reflected by the wide range of habitats in which cranes fed.

The flexible feeding strategy of cranes enables them to exploit patchy food resources efficiently. In our study areas, cranes were found foraging in pairs or family groups which often aggregated to form flocks. Some groups of cranes foraged for food among cattle, sheep, and donkeys, behaving much like cattle egrets *Bubulcus ibis*. They fed on insects flushed by grazing mammals. Temporary disturbance of foraging cranes due to burning, ploughing, livestock movement, and persons working within human settlements seemed to have little effect on the foraging pattern of the birds. Thus, the foraging sites of cranes were apparently not limited although food supply was not necessarily stable.

Inherent in the analysis of our data is the assumption that different habitat types represent distinct food resource bases. Consequently, changes in the abundance of cranes and the duration of habitat use reflect variations in the amount and probably the quality of food resources. Thus, the birds derived carbohydrates from seeds obtained from dry substrates and proteins from animal foods taken in different habitat types, particularly from the wet habitats. Outside the marshes, lone pairs of cranes were relatively few, indicating that grouping in cranes may serve to maximize feeding efficiency among other functions. Food abundance and dispersion, however, may not adequately explain the fragmentation or the temporary subgrouping of crane flocks. The social relationships among the group members may also contribute substantially to the formation of subgroups within a flock.

Aggregation in cranes may indicate changes in food supply as well as quality. Cranes tend to be more granivorous during the dry periods and their water drinking habit becomes more prominent in their daily activity pattern. Urban et al. (1984) noted that flocking in cranes occurs more extensively in eastern and southern Africa during the dry periods (i.e., nonbreeding season). In this study, it was

observed that more pairs and single birds occurred in the marshes (potential breeding sites) than in dry substrates. As suggested by Immelmann (1971), members of a pair exploit food resources more effectively than do unpaired birds. A pair is likely to benefit from the association because they influence each other and respond to environmental breeding cues or factors in synchrony.

In East Africa, the breeding season of crowned cranes is not clearly defined. The main breeding season at Saiwa Park is between August and November. Virtually all potential breeding habitats are occupied by nesting pairs of cranes. Flocks of cranes however, were found right in the middle of the main breeding period. The flocking birds frequently attacked those holding breeding territories. This suggested that a large proportion of the flocking birds failed to obtain nesting sites at the beginning of the breeding

season.

Marshes, such as those at Lake Ol Bolossat and Saiwa Park, are transitional habitats. The disturbance of such habitats greatly reduces biological productivity (Pianka 1974). Alterations due to cultivation, overgrazing, siltation, and frequent burning cause major changes in structure, composition, and productivity of the plant and animal communities (Pielou and Routledge 1976). Our results are indicative of low level disturbance of the crane populations. Thus, feeding habitats of cranes are still abundant and diverse in the wetlands of central and western Kenya. The flexible feeding strategy of cranes facilitates their accommodation to human settlements. A magnification of the disturbance level, however, could displace a part of the population and impose heavy constraints on the reproductive performance of the species.

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# THE ECOLOGY AND CONSERVATION STATUS OF THE GRAY CROWNED CRANE IN UGANDA

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## ABSTRACT

The gray crowned crane *Balearica regulorum gibbericeps* is Uganda's national bird, with a wide distribution. There is a great possibility, however, that its numbers will decline seriously over the next few years because the swamps where it breeds are being reclaimed for rice cultivation. The breeding biology of five pairs was followed in the swampy areas of Bunyole Connty, Tororo District. Seven other pairs were observed with young during the May to July breeding season. Of the 25 young, only 7 fledged, giving a low fledging success of 28%. The number of young in the population is generally low. Losses arise largely from capture by people interested in keeping the birds as pets or in selling them. Renesting success of gray crowned cranes was found to be low. Results are tentative but show a probable downward trend in the population. Therefore proposals are made for the conservation of cranes and their habitats.

## INTRODUCTION

Gray crowned cranes are large terrestrial birds which breed in swamps. The bird's wide distribution and its attractive appearance and behavior have resulted in several studies being made and other studies in progress. Changes in land use may threaten the crane, and therefore we need to know more of the bird's breeding requirements if we are to design an effective conservation program. Pomeroy (1980a, 1987) and Frame (1982) found that cranes lay two to three eggs with a productivity of about one young per pair per year. Estimates have put the crane population in East Africa at 70,000 birds (Pomeroy 1987), indicating that cranes are not in immediate danger of extinction.

There are some cranes in Uganda's national parks and game reserves, but they number no more than 20 pairs (Pomeroy pers. comm.). The low reproductive rate, loss of suitable breeding sites, and the capture of young are three important factors in the survival of the crowned crane in Uganda. The research is continuing, but this paper presents the data so far available and discusses the conservation implications of these findings.

## STUDY AREA

The main research site is situated in the swampy parts of Busolwe, Tororo District in Eastern Uganda (33° 55' E to 34° 07' E; 0° 45' N to 0° 58' N). Other areas studied are Kabanyolo, Namulonge, and Kasese.

In the Busolwe area, there are extensive low lying lands with rivers from Mt. Elgon running onto the flood plains and swamps. The main study area comprises some 400 km<sup>2</sup>, of which about one fifth is wetland. Broadly, there are two types of wetland. In deeper waters, papyrus swamps dominate with papyrus *Cyperus papyrus* about 3 m in height forming extensive single species stands. Secondly, there are

seasonal grass swamps. They are seasonal in that they contain less water during dry seasons, and extensive areas may dry out completely.

The waters of River Manafwa are now controlled under the Doho Rice Scheme and are periodically released for rice growing. Apart from the papyrus and grass swamps, the study area is characterized by open grasslands, wooded grasslands, and thickets. The most common trees in the swamp are *Acacia polyantha* and *Albizia zygia*.

The approximate percentage distribution of vegetation in the swamps of Busolwe area is given in Table 1.

Swamp	Approximate Percentage Vegetation		
	Grass	Papyrus	Cultivated Rice
Nakwiga	25	5	70
Nankwasi	30	50	20
Nahingande	80	-	20
Mukula	10	-	90
Namunasa	5	-	95
Lubembe	5	-	95
Doho	45	5	50

Table 1. Approximate percentage distribution of vegetation in the swamps of Busolwe area.

## METHODS

Crane movements were followed throughout the day. All places visited by cranes were recorded on a 1:5000 base map. The start of breeding was determined by the presence of single cranes, instead of the normally encountered pairs or flocks.

No attempt was made to approach the nests; instead termite mounds were used as observation points. At times I climbed trees.

The area was divided into study sites which were visited regularly. A study site was defined as the territory used by a pair of birds, consisting of a roosting site, nesting site or suspected nesting site, and the general feeding range. Ages of immature cranes observed outside the study sites were estimated by comparison with descriptions of chick development (Pomeroy 1980b).

Feeding ecology was studied through direct observations using 7x35 field binoculars.

## RESULTS

### Distribution and Population Size

Cranes were usually seen in pairs. Flocks of up to 42, however, were recorded in Doho, Kabanyolo, and Kasese. Most of the cranes sighted were adults. The young constituted a small proportion of the population. The percentage occurrence of pairs, families, and flocks of cranes in Busolwe area is given in Table 2.

Similar observations were made elsewhere; Pomeroy (pers. comm.), while visiting Kibimba Rice Scheme in October of 1986, found 32 cranes in different groups but only 1 young (five months old). During a survey of Kabanyolo and Kasese, I recorded flocks of 42 and 32 adults respectively, and no young birds.

Group Size	Percentage of Total Birds Seen
Pairs	13
Families 3-5	35
Flocks 6-25	52

Total number of cranes seen = 110; Total number of observations = 24

**Table 2.** Percentage occurrence of crane groupings in the Busolwe area, April to November 1986.

### Time of Breeding

Breeding in the Busolwe area started in May and lasted until about October, when single cranes could still be seen in the area.

### Breeding Habitats

Breeding habitats have been described by Pomeroy (1980b) and Frame (1982) and appear similar to those recorded in Busolwe. Cranes breed in seasonal grass swamps with grass about 1 m in height. No cranes were recorded in papyrus swamps. All recorded instances of crowned crane breeding ( $n=12$ ) in Busolwe occurred in grass swamps.

The number of breeding pairs and the percentage of each swamp reclaimed are given in Table 3.

Swamp	Estimated Size (km <sup>2</sup> ) <sup>a</sup>	Percentage of Swamp Reclaimed	Number of Breeding Pairs
Nakwiga	3	70	2
Nankwasi	10	20	2
Nahingande	3	20	2
Mukula	4	90	0
Namunasa	4	95	0
Lubembe	3	95	0
Doho	4	50	3
Muhusi	20	5	2

<sup>a</sup> size of swamp before reclamation

**Table 3.** Number of breeding pairs compared with swamp size and percentage of swamp reclaimed.

### Incubation

Incubation started on 4 May 1986 at study site 1. Judging from the number of single cranes seen after 4 May, incubation apparently started about the same time in other study sites. Both sexes incubate, the presumed female spending more time at the nest (in most pairs, one bird, believed to be the male, has a larger upper red face patch; also the presumed male makes louder calls). Apparently incubation at night is by the female at first, but later their roles are reversed. Table 4 shows crane activity for the pair at study site 1 as recorded on 14 May (nine days after incubation started).

Time	Sex	Activity
0630	C1	from roost to millet field
	C2	at nest
0823	C1	flies to nest
0828	C2	flies away from nest to water channel close to nest, later to millet field
1058	C2	flies back to nest
1105	C1	flies away to millet field to the north
1307	C1	flies back to nest
1315	C2	flies away to Muvle tree
1530	C2	flies back to nest
1533	C1	flies away to water channel and later to roosting place
1825	C1	to roosting place

**Table 4.** Crane activities during incubation as recorded on 14 May 1986. C1 is the presumed male; C2 is the presumed female.

During this 24-hour period, the male spent 5 h 08 min at the nest and 13 h 45 min away. The female spent 17 h 52 min at the nest and 4 h 09 min away.

Cranes exchange incubation duties. At study site 1, this happened four times a day at the beginning but changed to three times per day toward the end. Exchange times, during which one parent took over from the other at the nest,

ranged from 3 min to 30 min with longer intervals toward the end of incubation. No attempt was made to identify any exchange ceremony or activity because of thick grass cover and the risk of interfering with incubation.

#### Activities During Incubation Period

Apart from sitting on the nest or defending it, cranes spent considerable time feeding in the millet fields or water channels.

#### Nest Defense

During incubation, cranes are very aggressive, especially in areas close to the nest. On several occasions cranes chased away other birds that they found in or near the water channels or even birds they found perched on trees nearby. In areas where there were crane flocks, incubating cranes tended to keep to themselves. On two occasions, at Doho, single cranes trying to join flocks were repulsed. On another occasion, a crane was seen trying to fight a monitor lizard *Varanus niloticus* (about 50 cm in length) 250 m east of the nest at study site 1.

#### Hatching and Care of Young

Hatching was not easy to detect but was first noticeable by changes in the behavior of the cranes at the nest. For example, the exchange time was prolonged. On 4 June both cranes at study site 1 were away from the nest at the same time.

Hatching dates were also estimated on the basis of the incubation period mentioned by Frame (1982) and Johnsgard (1983). I noticed an interesting feature of the hatching process. Apparently egg shells were crushed and covered with a layer of grass. This behavior was observed in all the three nests I was able to find.

The young are fed primarily in the swamp. To be able to move with young, adult cranes trample over grass making paths along which they move. Several paths are made leading from the nest toward the periphery of the swamp. Paths are about 0.5 m wide and these sometimes lead to wider areas of trampled grass (5 m in diameter) where apparently most feeding takes place. Chicks are fed by both parents, which share the exercise. The pattern is such that one feeds while the other keeps watch at a distance. I was not able to determine the proportions of particular food items on which young were fed, but generally young are fed on grasshoppers and earthworms. Young cranes are fed throughout the day at short intervals of not more than 5 min. The frequency of feeding, however, is influenced by the brood size.

#### Loss of Broods and Renesting

Apparently all the five pairs that I studied lost their young. There were several other pairs in the vicinity with young that were reported to have been captured. The pair at study site 1 lost all the chicks by 20 June 1986. Thereafter they withdrew from the swamp. On or about 29 July, however, they started nesting again at a new nest 300 m

east of the original nest, and successfully hatched three chicks on or about 29 August. This pair again lost their brood on 30 October 1986. A second successful hatching was also recorded at study site 2 in late October, although by November this pair too had lost its entire brood. This loss happened before I was able to determine the number of young hatched. Later the pair visited the swamp less frequently and on 19 December 1986, they changed their roosting site to a place about 1 km southeast of their original roosting site.

#### Fledging

The overall fledging success for Busolwe area was very low. Table 5 shows the number of young that succeeded in fledging, 7 birds out of a total of 25 chicks hatched. Possibly the three young at Napekere were the same as those fledging at Mukula, which would mean the fledging rate was even lower.

## DISCUSSION

#### Breeding Success

Crowned cranes breed exclusively in swamps. In the Busolwe area, I found that they prefer seasonal grass swamps with grass of about 1 m in height. This preference probably serves to provide adequate cover for the incubating adults. Busolwe area has for a long time provided suitable breeding sites for cranes, and local informers told me that cranes breed in these swamps every year. The low percentage of young, however, in a population that breeds annually raises great concern. Hatching success in the Busolwe area is generally high — all the cranes that attempted to nest hatched some young. Although no eggs were counted, the low fledging success, 28% of chicks hatched (see Table 5), is an index of a low breeding success.

Two main factors are identified as being responsible for the low breeding success. One factor is the reduction of suitable breeding sites. Given that crowned cranes are known to have small migration ranges (Pomeroy 1987), loss of breeding sites may mean that cranes remain in marginal habitats where they cannot reproduce successfully.

The other factor is the capture of young by people interested in keeping them as pets. In an area of about 400 km<sup>2</sup>, however, there is only one tamed crane! This raises some curious questions as to what has happened to the rest of the young that are captured. Many young die because of poor handling. Trade in crane chicks, however, cannot be ruled out. I was invited on two occasions to buy crane chicks!

#### Conservation Status

From a brief survey of Busolwe area and from interviews with local residents, it is apparent that the number of cranes has declined in the Busolwe area since 1975, when rice cultivation gained momentum following the government's double production campaign. People recall that before 1975, there used to be many cranes. No numbers were given.

Location	No. of Young Observed/ Reported at Hatching	No. Fledged	Observer	Comments
Nakwiga I	2	0	Self	Captured when two weeks old.
Nakwiga II	3	0	Self	Lost when about one month old.
Doho I	2	0	Self	About one month old when last seen.
Doho II	2	0	Self	Captured when two weeks old.
Nahingande	3	0	Reported	Captured when one week old.
Mukula	3	3	Self	No parents seen.
Namunasa	1a	1	Self	With parents; there could have been more young at hatching.
Muwusi I	2	0	Reported	Reported captured after one month.
Muwusi II	1	0	Reported	Reported captured after one month.
Nankwasi I	2	0	Reported	Captured when about one month old.
Nankwasi II	1	0	Reported	Reported captured.
Napekere	3 <sup>a</sup>	3 <sup>b</sup>	Self	No parents seen.
	25	7		

<sup>a</sup> Assumed to be the number of chicks hatched, although no counts of young chicks were made in that area.

<sup>b</sup> It is likely that this group was the same one seen at Mukula because the three birds later flew toward Mukula (about 2 km west of Napekere)

**Table 5.** Fledging success for Busolwe area in 1986.

#### Local Disturbances

The level of human activity in the swamp also influences the ability of cranes to care for their young. This is especially true from June to August when people scare birds from rice fields. During these times, cranes sometimes spend up to one hour flying around or perched on a tree until they feel secure enough to feed their young. Hence some of these swamps have been rendered unsuitable for breeding even though the birds are not directly persecuted. Cranes are territorial and reportedly breed in the same area every year. In Busolwe nests were found about 150 m from the rice fields. With cultivated areas in all directions, cranes had small foraging ranges; the small size of these swamps was perhaps a significant problem when the cranes were caring for young.

#### Conservation Measures

Since the hatching success is high in the Busolwe area, it could be assumed that the crane population is viable. The population, however, is limited by the amount of breeding habitat available to it, and is threatened by further losses of suitable breeding sites as a result of increased swamp reclamation for rice cultivation. Conservation of crane populations in Busolwe and other parts of Uganda depends in the main on the preservation of sufficient breeding habitats to support viable populations. The price of rice is ever increasing and, combined with the ready market, makes rice cultivation preferred to other forms of swamp

utilization like cattle grazing and fishing.

In light of these factors, I would like to make the following proposals for the conservation of cranes and their habitats in Uganda.

- 1) The government of Uganda should set aside some swamps where breeding of cranes has been regularly recorded. This action would halt further reclamation of these swamps until proper assessment has been made of their value as breeding habitats for cranes. These swamps should be given a clear legal status.
- 2) In the already reclaimed swamps, rice growing should be done on a rotational basis so as to leave some areas fallow where cranes can breed.
- 3) The law concerning crowned cranes should be strengthened to include penalties for trapping, hunting, capturing young, and illegal possession of crowned cranes.
- 4) There is a need for an intensive publicity campaign through which the public will be made aware of the threatened status of the crowned crane and encouraged to take measures to safeguard cranes where they exist. This public awareness could have great impact, given that cranes can be easily habituated to people and that crowned cranes are not a potential pest. This education could be done through the Wildlife Clubs which are spread all over the country.
- 5) A long term crane monitoring system should be established. This effort will entail a regularly repeated census of cranes to determine their numbers in Uganda.



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## WETLAND CONSERVATION, WILDLIFE MANAGEMENT, AND HUMAN COMMUNITIES ON THE KAFUE FLATS, ZAMBIA

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### ABSTRACT

Although a large part of Kafue Flats is protected in two National Parks and a Game Management Area, the area is considerably used for pastoral practices and fishing. In addition, both banks are densely settled and cultivated, and water from the Kafue Flats is used for hydroelectric power and irrigation. Kafue Flats cover an area of over 6,500 km<sup>2</sup> in the south of Zambia, and are ranked among the country's major wetlands. The vegetation and the soil types are well suited for conservation of wildlife. The area has been regarded as the refuge for a number of wildlife species, especially Kafue lechwe *Kobus lechwe kafuensis*, which is the only species of lechwe present in substantial numbers. Furthermore, much of the hydrophyte vegetation is breeding habitat for many species of waterfowl. Nevertheless, the management and conservation of Kafue Flats are presented with serious controversies and threats of ecological and socio-economic significance. These conflicts have primarily been caused by the completion of hydroelectric dams in 1972 and 1978, and by the shortage of suitable land as the human population has rapidly grown. In introducing the objectives of the Zambia Wetlands Project, the paper critically examines whether current practices of resource exploitation, particularly wildlife, bear any relevance to the socio-economic status of communities in the area. The questions of who should benefit, and why, have become central issues in wildlife conservation in Zambia. Unless there is participation by the local government and inhabitants in exploiting wildlife for direct benefits, community attitudes of frustration and resentment will likely persist. Resources such as wildlife will suffer as a consequence.

### INTRODUCTION

The Kafue Flats are among the most important wetlands in Zambia. They are situated in the south of Zambia (15°20'55"S; 26°-28°E). They cover an area of 6,500 km<sup>2</sup> of floodplain grassland from Itezihitezhi Dam to the Kafue Gorge (Figure 1). Kafue Flats form a major component of the Kafue drainage system which covers nearly 154,000 km<sup>2</sup> (Chabwela 1986a). While the area seems to owe its origin to a buried lake, it is generally intersected by the meandering Kafue River, and its variable microrelief presents a complex pattern of lagoons, oxbow lakes, abandoned river channels, marshes, and levees. In normal years, much of the Flats are flooded. The water begins to rise soon after the onset of the rain season in November, but the peak flood levels are reached five to six months later. The minimum elevation in Kafue Flats is 1,065 m. Although records show mean annual temperatures (20.6°C) and mean annual rainfall (838 mm) to be favorable, there are significant variations among years. Soils in this area are generally not affected by the parent karroo or katanga rocks. They are predominantly alluvial clays, mainly the montmorillonite (Anonymous 1968).

Two large hydroelectric dams were constructed following recommendations by the Food Agricultural Organization (FAO) in 1966 (Williams 1977; Werger 1979). The first dam, located at Kafue Gorge below the Flats, was com-

pleted in 1972; a second storage dam, above the first dam, was commissioned in 1978. Although the scheme was originally intended for hydropower development, the reservoir was also to be used for fisheries and agricultural irrigation (Handlos 1982). The normal fall between the two dams is 15 m in 400 km (Rees 1978).

While the Flats are important for hydrology, agriculture, and fisheries (Anonymous 1968), they also serve as a major wetland wildlife reserve. They contain two National Parks, Lochinvar (440 km<sup>2</sup>) in the south and Blue Lagoon (410 km<sup>2</sup>) in the north (Figure 2). A Game Management Area (GMA) that surrounds both National Parks is also an important wildlife conservation area. Kafue Flats, particularly the hinterland of both banks, are densely settled. Events surrounding the creation of the protected areas (National Parks and GMA) and the construction of the two dams undoubtedly have made Kafue Flats the most disturbed wetland in Zambia. Dams have altered the flooding pattern of the area, thereby affecting livestock grazing, and breeding and feeding patterns of fish and wildlife. The existence of National Parks and GMA boundaries have caused great anxieties among inhabitants as accessibility to water and grazing has been hindered. This paper describes efforts of the Zambia Wetlands Project to determine what instruments would be most appropriate in the conservation and management of Kafue Flats, a wetland that has been severely disturbed and where concerns of wildlife and people have been in conflict.

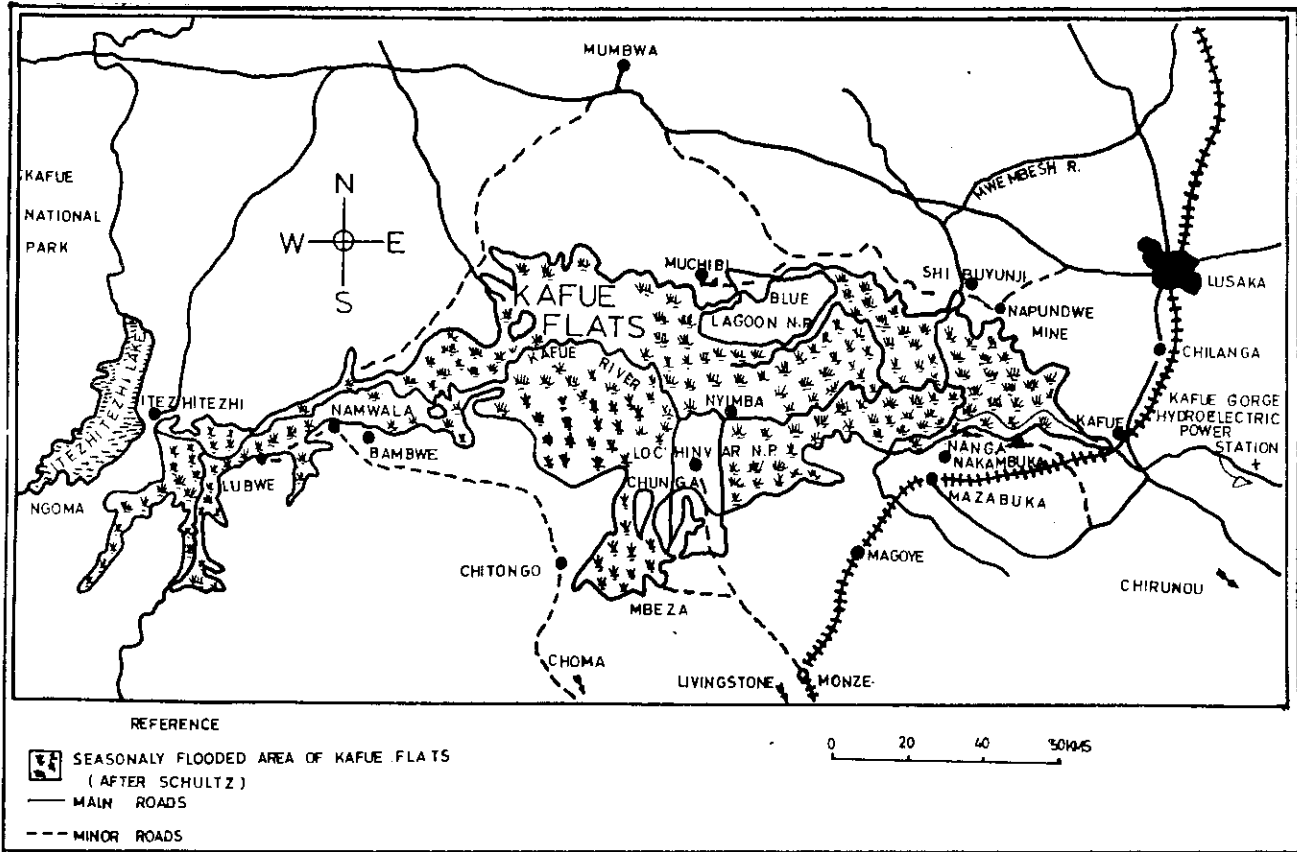


Figure 1. Kafue Flats and the adjoining areas.

ECOLOGY

Vegetation

Previous studies (Anonymous 1968; Douthwaite and Van Lavieren 1977; Chabwela and Siwela 1986) provide detailed accounts of the vegetation of Kafue Flats. These vegetation types represent the principal habitats of most wetland wildlife species. The main vegetation zones are woodland savanna, *termitaria* grasslands, and permanent swamps and levees. Their zonations are a result of flood contours and soil types.

Wildlife

While Kafue Flats are important for fisheries and grazing, the vegetation and the associated soil types are best suited for the conservation of wildlife. Kafue Flats are mostly dominated by lechwe and zebra *Equus burchelli*; other species that occur, but in limited numbers, are the wildebeest *Connochaetus taurinus*, buffalo *Syncerus caffer*, roan *Hippotragus equinus*, kudu *Tragelaphus strepsiceros*, and hippo *Hippopotamus amphibius*. Small mammals also have wide occurrence (Sharpe 1972).

Over 400 species of birds have been recorded in Kafue Flats, and of these 125 species are water birds (Douthwaite 1982). Their densities and occurrences, however, are closely related to the levels of the floods. There are 16 species of ducks and geese. Kafue Flats are internationally significant

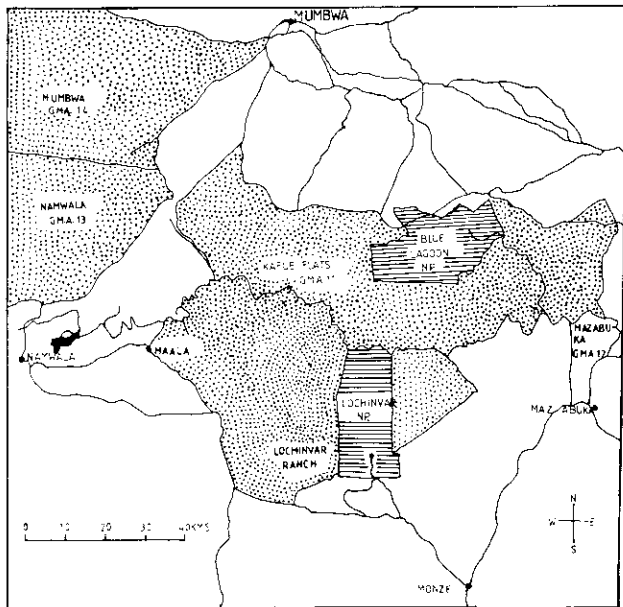


Figure 2. Part of the Kafue Flats showing the location of the National Parks and a Game Management Area.

wetlands as they support migratory birds as well as breeding birds. And during good flood years some species, including wattled cranes *Bugeranus carunculatus*, breed in Kafue Flats in large numbers.

#### Human Settlement

Despite limited prehistoric evidence, Kafue Flats may have been inhabited as early as 2000 B.C. by a race believed to have become extinct, and by the Batwa who are presently settled along the levees of the Kafue Flats and on the fringes of the floodplain. Kafue Flats are densely settled. Whereas data from unpublished reports (Chabwela 1986a) show the mean distance between large settlements at 75.5 km, the second stage settlements are dense with mean distances of 20.9 km on the south bank and 24.3 km on the north bank. Although some clusters of village units may show no distinct pattern of distribution, most of them are linearly confined to streams and edges of the Kafue Flats. Their mean distances are less than 5 km apart. Generally, the interaction of fields of influence show 52% of the settlements having allegiance to Kafue Flats for hunting, 42.5% for fishing, and 19% for grazing. This pattern is reversed, however, with the gradient from hinterland toward the floodplain, with village units located nearest the Flats showing more allegiance to Kafue Flats for grazing.

#### CONSERVATION

Unlike most other wetlands, Kafue Flats have enjoyed legal protection for nearly 20 years. Although Lochinvar and Blue Lagoon National Parks and the GMA should protect over half of the Kafue Flats, this arrangement has met serious setbacks for two reasons. First, the construction of the hydroelectric dams above and below the Flats was a clear indication that legislation on conservation can easily be overridden by other programs of national priority. The construction of the dams was in fact, carried out without regard to either the resources being protected or the welfare of the inhabitants of the area. Second, land shortage for crop agriculture, livestock grazing, and settlement is a serious problem in Southern Province, primarily because both human and livestock populations are rapidly growing. Thus the effects of the dams, combined with the effects of government intervention through the creation of protected areas, obviously have aroused public anxiety through the loss of land and of accessibility to water and grazing land. It is not surprising, therefore, that there has been continued hostility and resentment by inhabitants against both the construction of the dams and the creation of National Parks and the GMA. The inhabitants have realized no benefits from any of these developments.

Perhaps before a new set of proposals on the conservation and management of Kafue Flats can be discussed, we should examine the origin of the potential threat to conservation of this wetland. It is ironic that while in other parts of the world, wetlands are threatened by overdevelopment, the Kafue Flats are threatened as a direct result of the lack of infrastructure that could

facilitate management and conservation of this wetland, and a low priority given to the area during national development because of the assumed low economic output of the area. Traditionally, underdevelopment - in an area that has always been isolated, that has received no financial resources, and whose local inhabitants have usually been resistant to change - is evidenced by endemic food shortages, lack of health and education facilities, destruction of natural resources, and a general feeling of resentment by the inhabitants. Proximate factors to underdevelopment of wetlands are poor agricultural practices and poorly developed wildlife and fisheries resources as contrasted with the rapid growth of human and livestock populations. The resources of wetlands are largely over-exploited because disadvantaged communities, whether intentionally or otherwise, are destructive. In my view, over-exploitation and other devastating effects on resources are a result of the absence of adequate instruments (social or technological) necessary to cushion or divert the impact from community activities directed in search of food, land, or fuel wood.

#### DEVELOPMENT

Conservation of wetlands will invariably depend on evidence of their potential economic output. We should therefore examine the factors that cause the people living near wetlands to be mostly disadvantaged. Firstly, Kafue Flats should no longer be isolated but should be an integral part of the rural development. Secondly, more financial resources should go into the area so as to generate high economic output. And thirdly, an effort must be made to change the attitude of local people.

To achieve these goals, a scheme at the instigation of the World Wide Fund for Nature (WWF) and the government of Zambia is being developed in order to integrate the conservation and management of Zambia wetlands with the current rural development programs. The main emphasis of the Zambia Wetlands Project is to develop a model for an integrated land use based on a sustainable utilization of wildlife, fisheries, water, and land for agriculture and settlement with full local involvement. The scheme is in line with current policy on rural development, and intends to:

- (i) create self-reliant and progressing local communities near the wetlands;
- (ii) provide massive expansion of agricultural related industries; improve small scale rural enterprises and transform rural populations near wetlands into productive agents; and
- (iii) create employment, business, and mobility opportunities and improve the socio-economic infrastructure necessary for productivity within and around wetlands.

Elsewhere in the past these objectives have met considerable difficulties, primarily because the central issues of involving the intended beneficiaries in both the plan-

ning and implementing phases of development schemes were ignored. Instead such projects emphasized quick returns. In the absence of local consultation, project locations and outputs bore no relevance to the community needs. But under the current strategy, local people have been mobilized and have participated in initiating plans to implement specific objectives:

- (a) development of the utilization of wildlife resources so that profit opportunities and benefits resulting from commercial exploitation of wildlife resources (whether through safari hunting, harvesting, or tourism) will be retained in Kafue Flats for the community development;
- (b) development of fisheries resources so that inhabitants derive maximum financial benefits and also gain potential food sources; and
- (c) development of agricultural resources to allow for sufficient food supplies for the community, incorporating women in this aspect of community development so that women are involved in the decision-making at the planning, as well as implementing, stages.

#### SUSTAINABLE UTILIZATION OF WILDLIFE

Current attempts to conserve Kafue Flats through the Wetlands Project are based on the sustainable utilization of wildlife resources in the area. Perhaps in defense of our approach to conservation, a critical evaluation of the concept of wildlife harvesting should be reviewed. It has been stated in the World Conservation Strategy that the sustainable utilization of ecosystems and species requires knowledge of the productive capacities of these resources and measures to ensure that utilization does not exceed those capacities.

Whereas the concept of harvesting has been well developed in fisheries management (Ricker 1978), its application in wildlife management has met considerable resistance. Although the consensus is for the excess number of a population to be converted to a consumable resource, major disagreements exist on what should be the appropriate harvesting levels in any given population. Nearly every year ecologists and wildlife managers collect and analyze data, but rarely are bold decisions made on harvesting. And when such decisions are made, multiple management problems soon ensue. These difficulties may range from the clumsiness of the harvesting design itself to poor understanding of the species habitat, population, behavior, or distribution.

The most striking question, arousing endless debate among ecologists and managers alike, has been where on the growth curve can a population be harvested? One strategy is to harvest the population at its maximum number (i.e., when the population has reached the habitat carrying capacity) while another strategy aims at maximum yield (i.e., during the accelerating phase of the population's growth, at the point of inflection), or can one use common sense? Perhaps a quick review of the extent of the debate may help to clarify this argument.

The term sustainable yield (SY) is easy to understand but difficult to define because it means different things to different people. For example, while SY may refer to the number of animals that may be removed year after year from a population without causing it to decline (Caughley 1977; Savidge and Ziensenis 1980), economists have argued that the real yield from wildlife is not wildlife but dollars (Larkin 1977). The principles of harvesting as discussed by Caughley (1977) and Ricker (1978), however, emphasize the view that natural systems that are well managed will naturally provide substantial usable stock which could be tapped at any desirable level.

Theoretical levels such as the optimum sustainable yield (OSY) and maximum sustainable yield (MSY) have drawn considerable attention and discussion. Before the word "optimum" came into the literature, MSY was the traditional principle that occupied the minds of biologists, ecologists, and economists. Traditional opinion maintained that MSY was the most efficient level at which the population could be extracted. In theory, a population should not be harvested until the maximum potential rate of increase has been reached or the maximum slope of the growth curve has been located (Caughley 1977; Holt and Talbot 1978). If such a determination were possible, then the harvest could be taken from the self-regenerating stock of the animal species as desired without depressing its population. But as most critics have argued (Chapman et al. 1976; Larkin 1977), MSY theory can only be valid under a number of assumptions, such that:

- (a) MSY must assume that the unexploited population exists at an equilibrium density and that it is maintained by density dependant factors; and
- (b) MSY must assume that if members of a group of animals are harvested, they automatically will be replaced.

When such assumptions are examined, and particularly when we wish to examine them while attempting to manage natural systems where most variables are unknown, MSY proves to be an impractical management objective. In practice, MSY therefore does not exist or if it does, it cannot be found, and as such the concept has widely been abandoned, or may be applied mainly in mathematical models not intended for use outside the classrooms (Chabwela 1986b, in press). The introduction of the Optimum Sustainable Yield (OSY) therefore seems to have provided a possible alternative to the MSY. Proponents of the OSY have considered the concept as a most practical option for the optimum management of biological resources, as it also maximizes sustainable yield of social benefits (Krebs 1972; Larkin 1977). In the real world, however, this hypothesis does not make much sense. The term "optimum" is too qualitative and has no fixed point as in "Maximum" or "Minimum"; as such it is subject to considerable abuse. Nevertheless, the real consolations of this concept are that it allows for harvesting to be at a level that satisfies social needs of communities in question, and that harvesting can vary with the species and with the social, political, or market demand. Consequently, OSY

seems to be the most acceptable management objective, at least for now.

#### MANAGEMENT AND POLICY ON WILDLIFE HARVESTING

Safari and traditional hunting are the only current methods of harvesting wildlife in Zambia. While safari hunting has only been in existence since the early 1950s, traditional hunting has expanded, and is highly modernized. But despite the inevitable abuse of resources by both systems, the government policy on harvesting continues to be largely inadequate.

The question of common property resources was mostly discussed in the 1950s, for example by Gordon (1954) and Scott (1955), and recently by Hardin (1968) and Clark (1973). Exploiting resources such as wildlife (which are mobile and difficult to count accurately) depends on a fundamental extension in the moral responsibilities of the people concerned. In the absence of this moral responsibility, and also of an equitable system for regulating all resource users, wildlife species are open to direct abuse and eventually their numbers are likely to be drastically reduced. Collinson (1983) has strongly criticized the current arrangements for wildlife exploitation in Zambia. All costs of conservation are met by the government, the laws on harvesting are not stringent enough, and hunters are allowed into the hunting areas with minimal supervision. Whatever system of regulations (limited quotas or otherwise), this extension of freedom to hunters is subject to seriously abusive hunting practice which can cause rapid decline of wildlife numbers.

Perhaps one approach that has not been tried but requires serious consideration is for all resource users (hunters and everyone else) to receive training in resource exploitation. In some regions (Bubenik 1976; Carter and Toule 1977), a person cannot be allowed to hunt without successfully completing a formal hunters' training. In parts of Europe, for example, training takes 30-65 hours of official instruction in conservation laws, biology, game ecology, hunting and management operations, game diseases, feeding of game, gun types and mechanisms, ballistics, and shooting. Resolving immorality through punishment, as is the case at present, cannot be successful unless the question of hunter education is critically examined.

Often harvesting programs have failed because they have not been backed by relevant knowledge of the species being exploited. This view has been strongly expressed by Collinson (1983). The work by Gatto (1976) provides a good example of how cropping schemes or any harvesting program should be pursued. What he did was to undertake the determination of primary production, energy budget, and the population size of the blesbok *Damalimus dorcus Phillisii* before any quotas could be established. Population size, distribution, species behavior including breeding and feeding, population structure, and habitat studies should form the basis for determining the numbers of animals that should be harvested. Walters and Bandy

(1972), Caughley (1977), and Savidge and Ziesensis (1980) have discussed various responses of wildlife populations to harvesting, although such responses vary with the species' behavior. Good knowledge of such population responses is essential for any effective management. Therefore, it would be unrealistic, and unfortunate, for a government to determine quotas outside these parameters.

Chambers (1974) and Chabwela (1986b) have complained over the lack of participation of the rural inhabitants in development programs that take place within their area. Wildlife is a rural based resource, and potential exploiters are the rural people; but as they are poor, remote, isolated, powerless, vulnerable, and lack influence, they have been virtually neglected; current hunting administrative arrangements seem to be against them. Predictably, therefore, their reaction of resignation and resentment, and the catharsis of their frustration, are severely imposed on wildlife. And thus Collinson (1983) contends that cropping schemes have failed in the past partly because their designs have lacked the component of local involvement.

#### GRASS ROOTS APPROACH

Consequently, the planning and implementation of the Wetlands Project at a grass roots level assumed three important steps:

First, it was necessary that local leaders such as chiefs, wardchairmen, headmen, businessmen and prominent farmers were consulted for the purpose of seeking their views on the conservation resources in the area, and of determining their felt needs and how these were being resolved in relation to the available resources. As a way of involving local people from the beginning, this was a significant step because it allowed the project concepts to be explained to the people and also sought the initial commitment by local people to the project.

Second, a workshop was convened in which local representatives of the technical, professional staff and the policy makers of various agencies in the area and of the Ministries concerned met to discuss project concepts and the views expressed by various local leaders. Furthermore, while the workshop worked out the appropriate project structure, it also determined the methods of implementation within the context of the Zambian law so that revenues to be accrued by project activities would be retained in the area for local development.

Third, after obtaining the local commitment in the second step, implementation was then possible. According to plan, the project's main focus at a community level was to develop local will and skills through training of community leaders, establishing Community Development Units, Area Committees and forming the overall authority for administering resources in the area. While there was need for stock improvement of fish and wildlife species, the community also considered it desirable to establish a permanent resource basis and to develop and improve the infrastructure for the effective management of resources.

Unlike the traditional approach in conservation projects, our findings using the grass roots approach seemed to provide answers to the community issues which could not be dealt with from outside. In fact, the understanding by local leaders is that the development of resources in the area was a project initiated and kept by them.

## CONCLUSION

The present discussion does not answer all the questions about how Kafue Flats could be conserved, but it does demonstrate that there are approaches (both direct and in-

direct) that should be considered in the conservation of wetlands. A main difficulty for wetlands conservation results from the term "wetland" being relatively new in Zambia. But the principal conclusion in this discussion is that substantial resources can be sustained and could be used on a sustainable basis in the Kafue Flats with the presence of adequate infrastructure, the placement of more financial resources in the area, and sufficient involvement of the local inhabitants in policy decisions. Thus while legal obligation presently exists for the protection of the wetlands and their wildlife and fisheries, ultimately there is only one way to succeed: to give local people some direct benefits from conservation.

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# THE BREEDING BIOLOGY OF THE WATTLED CRANE IN NATAL

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## ABSTRACT

Natal supports about 104 breeding pairs of wattled cranes *Bugeranus carunculatus*. The breeding range is confined to the west of Natal where cold marshy grasslands occur. The majority of breeding marshes support only a single pair and territoriality is clearly defined when two or more pairs are present. Nest sites are never less than 400 m apart. The breeding season is extended but has a peak in mid winter. Clutch size is one or two with single-egg clutches predominating. Egg losses are high, with only about half the recorded clutches hatching. Eggs in one-egg clutches are heavier than eggs in two-egg clutches, but the combined weights for two-egg clutches are much heavier than the single eggs in one-egg clutches. Renesting is usual after a breeding failure. The newly hatched chick remains on the nest for only one day and then follows its parents. Only about half the observed chicks reach the fledging age of 3-4 months. Fires are an important source of mortality. Juveniles remain with their parents for up to a year before being driven away prior to the next breeding attempt.

## INTRODUCTION

The wattled crane is one of Africa's rarest birds. A few censuses have been conducted in Zambia (Douthwaite 1974; Howard and Aspinwall 1984), but most reports from other parts of Africa (Vesey-Fitzgerald and Beesley 1960; Urban and Walkinshaw 1967; Procter 1968; Konrad 1981) lack population estimates. More recently Tarboton (1984) and Geldenhuys (1984) published detailed accounts of the wattled crane in the Transvaal and the Orange Free State.

The Natal population was almost unknown until Day's (1980) report. One of us (PRB) commenced monitoring wattled crane nests independently at about the same time. A summary of his findings appears in Tarboton et al. (1987). Much of the breeding data collected contrasts with that from the Transvaal and prompted a more detailed investigation.

## METHODS

The first aerial census was conducted during the winter of 1982. Winter was considered the ideal time because it was the peak of the breeding season, when the cranes were most sedentary. The census covered the entire range of the wattled crane in Natal and consisted of seven flights, undertaken when weather conditions were clear. Observations were made at a height of 100 m above the ground at a speed of 90 km/hour. Cranes, and their nests and eggs, are readily visible under these conditions. Ideally flights should have taken place on consecutive days to avoid errors incurred by crane movements, but this proved impossible.

Most nest sites found before and during the aerial survey were visited on foot. Active nests were inspected every 1-3 months to determine the outcome of nesting attempts.

Further aerial censuses were conducted in every winter from 1983 to 1987, but because of other demands on the

plane, only three or four flights were possible each winter.

Eggs and chicks were weighed with a Pesola scale.

The age at which chicks first flew was determined by chasing a near-fledged chick to test its reaction.

## CENSUS RESULTS

Fifty pairs of wattled cranes were found to be breeding during 1982. Another 35 pairs were found in territories where breeding had taken place in previous years but showed no definite evidence of breeding during 1982. A further 19 breeding pairs were found subsequent to 1982 by more careful searching in areas where cranes had been assumed absent. All of the breeders and potential breeders were located on permanent sponges. The distribution of breeding territories is given in Figure 1. In addition, 56 floating birds were counted in 1982. Floaters showed no tendency to pair and occurred in groups of variable size. They were also more wide-ranging than the breeders and were not confined to sponges. Between 1983 and 1987 the number of floaters varied greatly. For example, in 1986 a flock of "over 100" was reported from the Orange Free State, just over the Natal border, presumably the Natal floating flock.

The Natal population of wattled cranes is thus about 280. Errors in this figure must be fairly small. Although not all sponges were occupied during any one census, not one was abandoned permanently. Accuracy in counting the floaters was necessarily lower than in counting breeders. On most censuses, however, all or nearly all the floaters were found in a single day, sometimes in a single flock, so even here accuracy was high.

In the Natal Bird Atlas (Cyrus and Robson 1980), records of wattled cranes to the east of the 1982 range are presented. The aerial census did not locate these birds.

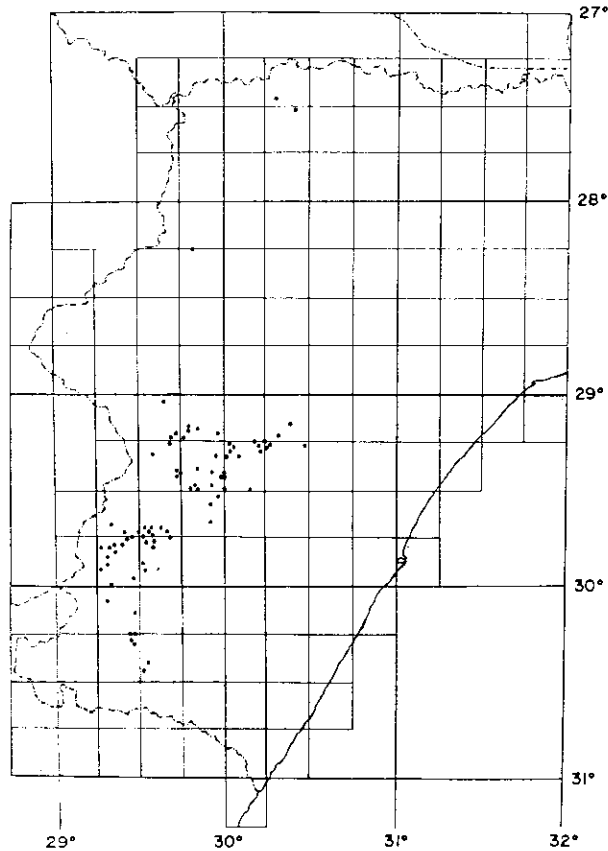


Figure 1. The distribution of wattled crane nests in Natal.

The current breeding range is confined to the cold open grassy area in the west of Natal. The southern extremity is near Franklin in East Griqualand and the range skirts the Drakensberg foothills extending northwards to the Estcourt area in the west and the Umvoti area in the east. There is one isolated breeding pair north of the main range near Fort Mistake, and two further pairs in the far northwest.

Most wattled crane nests are still located on private land. There has been a considerable improvement, however, in this situation since the beginning of the study. Then the only nest sites in reserves were those at Coleford, Himeville, Stille Rust and Highmoor. None of these reserves had been proclaimed because wattled cranes nested there, so the protection afforded them was entirely fortuitous.

The first acquisition made by the Natal Parks Board specifically on behalf of the wattled crane was The Swamp in 1984. Only a single nest is present, but the site is very productive, a chick being fledged almost every year. Crowned cranes also nest there.

Umgeni vlei and Woodhouse were acquired in 1987. These farms are adjacent, and together were proclaimed the Umgeni Vlei Nature Reserve. Ten pairs nest in the reserve, seven of them in the main vlei.

Melmoth was acquired in 1989. Three pairs nest there. The property adjoins the existing Karkloof Nature Reserve

and is now part of it. Scope for enlarging the reserve to incorporate extra wattled crane nest sites exists.

By far the majority of sponges that maintained wattled cranes only supported one pair. Eighty-two of the 89 breeding sponges supported a single pair, 3 held 2 pairs, 3 held 3 pairs and 1 held 7 pairs. Intuitively it would seem that wattled cranes are highly territorial, especially as some of the single-pair sponges (e.g., Stille Rust) were large.

The sponges which each supported two or more pairs of wattled cranes were large or elongated. For example, Connemara vlei was particularly long and winding, and a spur of high ground ensured that the two nest sites were out of sight of each other. Killarney vlei was larger than most other vleis and its three pairs were well spaced out.

Mgeni vlei was by far the largest of the breeding sponges and the distribution of its seven pairs is illustrated in Figure 2. The squares indicate the position of nests from 1982 to 1985. The circle represents a new pair which became established in 1986. Water flow is from west to east. Water depth in the central part of the large open area is generally too great for wattled cranes. The eastern end is enclosed by steep hillsides and, in places, cliffs.

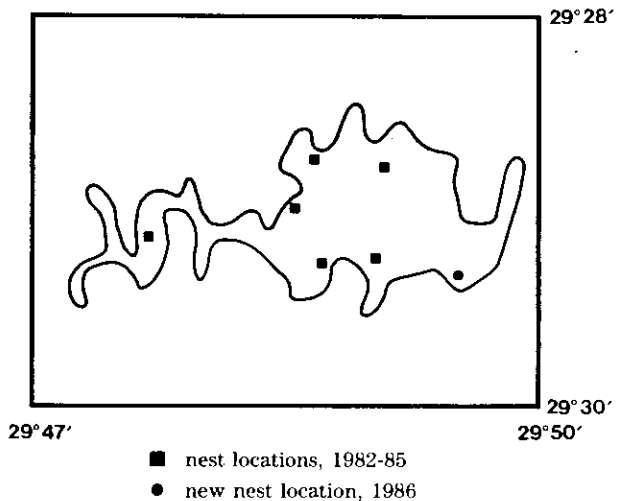


Figure 2. The distribution of wattled crane nest sites in Umgeni Vlei.

Territorial interactions between adjacent pairs were never observed. The distribution of nests, however, within the suitable part of the vlei (i.e., excluding the deep and enclosed areas) is clearly over-dispersed, and this can only be the result of well-developed territoriality.

Five of the Mgeni nests are within sight of each other. The shortest distance between neighbors is about 400 m, the greatest distance about 600 m. In round figures therefore, a pair of wattled cranes "likes" a territory in the region of 0.25 km<sup>2</sup>.

#### SEASONALITY OF BREEDING

The months in which clutches were laid were determined by direct observation and by extrapolating back from known age young. Results are summarized in Table 1.

	Number of clutches laid in each month							
	A	M	J	J	A	S	O	N
1980-1981	3	7	4	6	3	6	6	3
1982	2	9	19	12	5+2 <sup>a</sup>	1+2 <sup>a</sup>	1+1 <sup>a</sup>	1+1 <sup>a</sup>

**Table 1.** Wattled crane egg-laying dates in Natal in 1980-82.

<sup>a</sup>Repeat clutches.

The laying season is extended, commencing in April and lasting until November. The best data comes from 1982 when observations were most intensive and coverage more complete. Although long, the season was nevertheless clearly defined with a June peak and no subsidiary minor peaks. The season had a slight "tail", probably a function of repeat clutches laid after the first breeding attempt had failed. Not improbably all the late clutches were reneesting attempts but definite proof is lacking.

Data collection in 1981 and 1980 was patchy. In particular there was no aerial survey so that less accessible areas were not visited. Thus, no conclusion can be drawn from the apparent lack of a mid-season breeding peak.

The breeding peak in June coincides with the coldest and apparently least hospitable time of year. This may not at first sight appear adaptive but the selective pressures molding the breeding season are complex. There are a number of relevant factors to consider, and these can be discussed when we have examined other aspects of the breeding cycle.

#### CLUTCH SIZE

Clutch size was observed in seventy nesting attempts. Results are presented in Table 2. Single-egg clutches were observed in 43 cases, two-egg clutches in 27 cases. Single-egg clutches clearly displayed the June peak already identified from the summary of all breeding evidence. Two-egg clutches showed the same general pattern but without the sharp June peak. This apparent difference was not significant.

	Number of clutches laid in each month								
	A	M	J	J	A	S	O	N	Total
Clutch size 2	1	6	6	5	3	2	3	1	27
Clutch size 1		7	13	6	8	4	1	4	43
Total	1	13	19	11	11	6	4	5	70

**Table 2.** Clutch sizes of wattled cranes in Natal in 1980-82.

#### EGG WEIGHTS

The weights of eighteen complete clutches of eggs were measured and results are given in Appendix 1. In most cases there was no direct way of knowing at which stage of incubation the eggs were measured. The laying weights and density of the Forest Lodge clutch were known, however, and as no other eggs were found with a higher density it has been assumed that all eggs were laid at a density of 1.10. Similarly, hatching densities varied little around a mean of 0.86. None of the unhatched eggs had densities

lower than this figure. The density of any egg can therefore be used to produce an "extrapolated laying weight." This figure is necessary if we are to draw any conclusions about fresh egg weights.

Egg weights varied from 186 g to 338 g. Variation, however, was not so great if the eggs were considered in different categories, Table 3.

	n	Mean	Range	S.D.
Single egg	10	272	235 - 338	27.7
First egg of two	8	243	218 - 276	19.0
Second egg of two	8	207	186 - 241	19.2

**Table 3.** Mean fresh weights of eggs laid by wattled cranes in Natal in 1980-82.

Single eggs are significantly heavier than eggs from two-egg clutches;  $t=2.63$  for the difference between single eggs and the first egg of the two-egg clutches. There was also a significant difference between the first and second eggs in two-egg clutches,  $t=3.77$ .

The ranges of all three egg categories overlap, although those of single eggs and second-of-two barely do so. Thus, although the means of the single eggs and first-of-two categories differ significantly, it does not mean that the bird, or some facet of its physiology, has decided in advance what size the clutch is to be. There is some flexibility. It does appear, however, that there is a limit to the resources a bird is prepared to put into any one clutch. If the first-laid egg is small enough it may be followed by a second, slightly smaller egg. If it is large, there will not be a second egg.

#### EGG WEIGHT LOSS

Egg weight loss was carefully monitored at Forest Lodge in September and October 1982. Results are presented in Table 4.

Date	Egg 1		Egg 2	
	Weight (g)	Density	Weight (g)	Density
	105.2 × 62.8 mm V = 210.36 cc		99.0 × 58.7 mm V = 172.97 cc	
28-9	232	1.10		
29-9	232	1.10		
30-9	231	1.095	189	1.09
3-10	225	1.07	183	1.06
7-10	219	1.04	181	1.05
11-10	213	1.01	175	1.01
15-10	206	0.98	172	0.99
18-10	203	0.97	170	0.98
23-10	196	0.93	165	0.95
31-10	183	0.87	159	0.92

**Table 4.** Weight loss of a wattled crane clutch during incubation at Forest Lodge in September-October 1982.

Volume was calculated using the technique described by Furness and Furness (1982). Accuracy depends upon the symmetry of the egg, not its shape, and as wattled crane eggs are very nearly symmetrical any errors must be small.

The larger egg pipped on 31 October and hatched on 1 November. The second egg was then abandoned and found to be addled.

Rate of loss of density is plotted in Figure 3. Linearity tests were not performed but for practical purposes density loss in the fertile egg was linear. Density loss in the addled egg was initially more or less linear, although subsequently density loss was less than that of the fertile egg. It could be concluded therefore that most density loss was caused by evaporation and that metabolic losses only manifested themselves toward the end of incubation when the chick was almost fully developed.

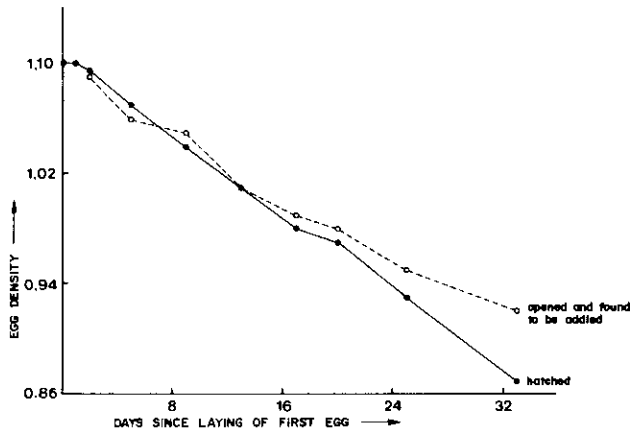


Figure 3. Loss of density in a two-egg clutch during incubation.

There were four cases where hatching weights and densities of eggs were known and results are presented in Table 5. With one exception, hatching density was almost uniform, range 0.85-0.87. The exception was the second Winchester egg which under natural circumstances would never have hatched.

Knowledge of laying and hatching densities and of rate of density loss has important research and conservation implications. It means that one visit to a nest is sufficient to establish when the likely hatching date will be.

Locality	Date	Hatching Weight (g)	Hatching Density
Forest Lodge	1-11-82	183	0.87
Winchester (Egg 1)	23-7-82	201	0.85
Winchester (Egg 2)	27-7-82	150	0.79
Yorkville	18-10-82	214	0.86

Table 5. Densities of wattled crane eggs about to hatch in Natal in 1982.

#### HATCHING SUCCESS

The outcome for 49 clutches was known. Twenty-eight of these were one-egg clutches, 21 were two-egg clutches. Results are presented in Table 6.

The productivity of two-egg clutches appeared slightly lower than that of one-egg clutches but the difference was not significant.

Outcome	One-egg Clutches	Two-egg Clutches
Hatched	16	11
Destroyed by fire	1	
Destroyed by hail		1
Flooded		1
Addled	2	2
Disappeared	9	6
Chicks/clutch	0.57	0.52

Table 6. The outcome for 49 clutches of wattled crane eggs in Natal in 1980-82.

Twenty-two clutches failed to produce a chick. Only one nest was lost to fire even though the majority of clutches are laid at a time when fire risk is greatest. Doubtless the moat created by the parent birds around the nest gives protection from fire. Hail was not a major threat, as the majority of birds have finished laying before the hail season arrives. One nest was lost to a natural flood, again a hazard to which only very late nesters are exposed. Four clutches were addled.

The causes of the loss, however, for most clutches were not known. Fifteen clutches simply disappeared before hatching. It is unlikely that any of these rolled out of the nest because the nest has a substantial concavity. While evidence is totally lacking, it can only be presumed that predators, including unauthorized human interference, are responsible. A lack of egg fragments at an empty nest does not exonerate predators because nesting birds meticulously remove broken eggshells after a chick has hatched and might well do so under other circumstances.

Two-egg clutches never produced more than one chick. Typically the second egg was laid 2-3 days after the first, with incubation beginning before the appearance of the second egg. Not surprisingly hatching was never synchronous. In the one carefully documented case, the clutch of 28-30 September, 1982 at Forest Lodge, the first laid egg hatched first and the second egg turned out to be addled. Incubation continued for 1-2 days after hatching until the chick was strong enough to leave the nest. The other egg was then abandoned.

In the 10 cases where the parents with a two-egg clutch produced a chick, the second egg never hatched. Outcomes for these eggs were: addled, 1; fully formed but abandoned, 4; chipped but abandoned, 1; hatched after first egg was experimentally removed, 1; and unknown, 4. In five of the six known cases, the second egg was fertile and would have produced a chick after only 1-2 days further incubation. One of these eggs had actually chipped and the unhatched chick had presumably been calling for a day previous to that. Yet still the parents abandoned it.

That the second egg was fully viable was proved experimentally. On 23 July 1982, the most advanced egg of the Winchester clutch was calling. This egg was substituted for the egg of the Alida Mount pair which was known to be addled. The substitute egg was accepted by its new parents and hatched shortly afterwards. The remaining

Winchester egg, which would invariably have been abandoned, started calling and chipping on 27 July 1982. It hatched on 28 July 1982, producing a normal, if rather small chick.

#### EGG ADDLING

Seven of the 70 eggs under observation turned out to be added, a rate of 10%. Six of these eggs were opened and results are presented in Table 7.

Locality	Laying Date	Egg Collected	Interval (days)	Degree of Development
Alida Mount	28-5-82	23-7-82	56	None
Llewelyn (1)	21-5-82	9-8-82	82	3/4
(2)	23-5-82	29-8-82	98	None
Elgin (1)	18-7-82	23-10-82	98	1/4
(2)	20-7-82	23-10-82	96	1/4
Kildare	21-5-81	14-7-81	54	None

**Table 7.** The histories of six addled wattled crane eggs collected in Natal in 1981-82.

Three of the eggs were completely undeveloped and in the other three some development had taken place. Incubation periods varied from 54 to 98 days but these figures are misleading because in all cases incubation only ceased when the researcher intervened. The cranes appeared prepared to sit on a lost cause forever. The adaptive significance of this is not clear. Since addling is not a rare event one would expect some mechanism enabling the rejection of eggs which had no hope of hatching. Subsequent to the artificial removal of the addled eggs, one of the four pairs concerned (Kildare) relaid. Two eggs were observed on 24 August 1981; although this clutch failed because of natural flooding, the eggs were fertile. An obvious conservation measure therefore is carefully to monitor nests towards the end of the normal incubation period and remove eggs as soon as it is established that they are addled. It is reasonable to suppose that the Llewelyn pair would have relaid if they had been relieved of their eggs two months earlier.

#### HATCHING WEIGHTS

Five newly hatched chicks were weighed and results are presented in Table 8. Newly hatched chicks stay on the nest for only 1-2 days. It is only during this period that it is possible to catch the chicks and weigh them. Hence the paucity of records. As soon as chicks are strong enough they leave the nest and swim through the vleis to join the parents.

Locality	Date	Weight (g)
Moorgate	16-7-82	163
Middle Draai	18-8-82	176
Yorkville	18-10-82	164
Forest Lodge	1-11-82	135
Winchester	28-7-82	114

**Table 8.** Weights of newly-hatched wattled crane chicks in Natal in 1982.

The Winchester chick was the only chick known to have hatched from the second egg of a two-egg clutch. This was a consequence of the transfer of the first egg to the nest at Alida Mount. The second chick was notably lighter than "normal" chicks and presumably had smaller survival prospects.

#### POST HATCHING CARE

The newly-hatched chick stays on the nest for only 24-48 hours. During this time one or the other of the parents is usually in attendance.

Food is not brought to the chick. The parents, however, give to the chick fragments of its own broken eggshell to eat. When this supply is exhausted the chick swims across the moat and follows the parents around in the drier parts of the vlei.

After leaving the nest, small chicks are rarely seen. The parents are wary of approaching observers and most successful at hiding the chick. They then stalk observers closely, often at a distance of 20-30 m, presumably being prepared to step in, or at least try to create the impression that they will, should further defense of the chick prove necessary. This behavior is only relaxed when the observers leave.

The chick stays with the parents for at least seven months. At this age it closely resembles the parent except that it may not be quite full size and that its wattles are poorly developed. Any time after this, the chick will be actively driven away by the parents when they are ready to breed again.

#### CHICK SURVIVAL

The careers of 45 chicks are known with a reasonable degree of certainty. Details are listed in Appendix 2 and a summary is given in Table 9. Fifteen out of 45 chicks survived to fly and presumably to adulthood since an adult-sized bird is exposed to few risks. Of those still alive but not yet flying, an intuitive guess is that 6-7 would reach the flying state. In round figures therefore chick survival is 50%.

Career	n
Survived to flying state	15
Still alive, age 1 month	2
Still alive, age 2 months	7
Still alive, age 3 months	4
Killed by hail	2
Burnt	5
Died on nest	1
Disappeared before flying, age 1 month	5
Disappeared before flying, age 2 months	1
Disappeared before flying, age 3 months	3

**Table 9.** Survival statistics of 45 wattled crane chicks in Natal in 1980-82.

Grass fires are the most important known cause of chick mortality. July is the peak hatching month and by this time the winter drought is always well advanced. Accidental

fires are not unusual and vleis burn as easily as dry grass areas. Unauthorized deliberate fires also occur. The fire risk greatly increases in August when farmers are officially permitted by the Department of Agriculture to burn old long grass to improve the coming season's growth. The number of burns increases during September at a time when the majority of chicks are still unable to fly. After September little unburnt long grass remains, the rains begin and most chicks can fly, so fire is no longer a hazard.

Fire risk could be greatly reduced by careful management. An optimal way of managing grassland is to divide it into blocks with firebreaks and burn only those blocks which require it. It would then be simple for any conservation-oriented landowner to burn a block only when the wattled crane chick was known to be elsewhere. Unfortunately this attention to detail is seen all too little.

Important though grass fires are, however, they account for fewer chicks than other, unknown sources of mortality. Nine chicks "disappeared" compared with the five which were burnt. As was the case with disappearing eggs, it can only be assumed that predators were responsible.

Hail accounted for two chicks. Hail is only a hazard during summer when comparatively few chicks are still flightless.

It is important to note that 45 chicks examined are those which had survived until first noticed by the field observers. Chicks which had hatched and died before being noticed could not be included in the analysis. The quantitative effect of this error is unknown but its presence means that the real chick survival rate is less than estimated on the basis of figures available.

#### AGE AT FIRST FLIGHT

Age at first flight could not be determined with absolute accuracy since this would have involved a daily chase of any chick approaching flying age. There were four cases, however, where age at first flight was known with some accuracy (Table 10). In three of the cases this age was just in excess of three months. The Himeville chick only flew

after 128 days but this figure is accurate since the chick was unable to fly when chased at 121 days of age (D. Roberts pers. comm.).

Subjective evidence suggests that some chicks cannot fly until at least 120-130 days because three and four-month old chicks have several times perished in grass fires. The only firm conclusion therefore is that age at first flight varies considerably with a known range of 91-128 days.

Locality	Hatching Date	First Flight	Age (days)
Himeville	20-5-82	25-9-82	128
Banavie	5-10-80	4-1-81	91
Stille Rust	21-6-82	24-9-82	94
Middle Draai	15-9-81	22-12-81	98

**Table 10.** Ages of first flight of wattled crane chicks in Natal in 1980-82.

#### RENESTING ATTEMPTS

Unlike the Transvaal population of wattled cranes, the Natal population exhibited a well-defined breeding season. It was thus possible to identify renesting with some certainty. All documented cases are presented in Table 11.

A total of twelve pairs renested during the study period, one of them twice in the same season. Renesting attempts obviously occurred later in the breeding season, the earliest attempt being noted in August. That does not mean, however, that renesting is confined to birds laying their first clutch early in the season. The Potatoes, Banavie and Scawby Top pair renested after a September start. The Stadlers Rust pair managed two further attempts after a June start.

There were no instances of a pair "starting" a new season early by renesting after a late failure in the previous season. Those few pairs which did have eggs in April or May had not previously laid for a year or more.

The outcome of eleven of the renesting attempts are known. Seven hatched successfully. The Stille Rust clutch

Locality	First Clutch Present	Date Failure Noted	Reason For Failure	Second Clutch Present <sup>a</sup>	Outcome	Reason For Failure	Third Clutch Present
Forest Lodge	23-4-82 (1)	31-8-82	Chick disappeared	30-9-82 (2)	Hatched		
Stadlers Rust	1-6-82 (2)	5-7-82	Eggs disappeared	7-8-82 (2)	Failed	Eggs disappeared	29-11-82 (1)
Winchester	24-6-82 (2)	24-8-82	Chick burnt	2-10-82 (2)	Hatched		
Stille Rust	1-4-81 (2)	?-5-82	Chick dead on nest	1-10-81 (2)	Failed	Egg destroyed by hail	
Highmoor	23-6-82 (1)	5-7-82	Egg disappeared	23-8-82 (1)	Hatched		
Potatoes	5-7-82 (1)	27-7-82	Egg disappeared	1-9-82 (1)	Unknown		
Dargavel	?-5-81 (1)	31-8-81	Chick burnt	13-10-81 (2)	Hatched		
Kildare	17-5-81 (1)	14-7-81	Egg addled	24-8-81 (2)	Failed	Nest flooded	
Banavie	24-7-81 (1)	Not recorded	Unknown	Hatched 1-12-81	Hatched		
Mount le Seuer	13-5-81 (1)	?-6-81	Egg disappeared	?-9-81 (2)	Failed	Eggs disappeared	
Scawby Top	15-9-81 (1)	?-9-81	Egg disappeared	21-10-81 (1)	Hatched		
Scawby Bottom	?-7-81 (?)	?-8-81	Chick disappeared	?-9-81 (?)	Hatched		

**Table 11.** Renesting attempts by wattled cranes in Natal in 1981-82.

<sup>a</sup>clutch size indicated in parentheses.



was destroyed by hail - a hazard unique to summer. The Kildare clutch was added, as had been its predecessor. Two clutches disappeared. This success rate of 7/11 compares favorably with the success rate of all other clutches whose outcome was known (including failed first clutches). Other clutches scored 20 successes out of 39.

The urgency with which wattled cranes re-nest was particularly well illustrated by events at Forest Lodge during 1982. The resident male died from unknown causes on 31 August 1982 and the three-month old chick disappeared at the same time. A new male had moved in by 4 September 1982 and the female laid the first egg of a new clutch, in a new nest, on 29 September 1982. Events could hardly have moved faster if the original male was still present.

## DISCUSSION

A number of interesting questions are posed by the data presented here. Why is the wattled crane rare? Aerial photographs of the Natal Midlands taken in 1950 show that twice as many vleis were present then. Those that have vanished are now dams or pastures. Thus, an obvious suggestion is that breeding sites are limiting, and they are certainly in short supply. The strong territoriality displayed by the wattled crane, however, suggests otherwise. Why are the Mgeni vlei nests so neatly dispersed? Within each territory there a nest could be built almost anywhere. Could food be limiting? There is little quantitative information on the diet of the wattled cranes, but qualitative field observations suggest that the underground storage organs of vlei plants are favored and that small quantities of a variety of other foods are eaten. Subjectively, the size of the breeding territory seems large in relation to the chicks' requirements and indeed no starving half-grown chicks have ever been found. All that might prove, however, is that the territorial system for ensuring a food supply is working well.

Why do wattled cranes preferentially nest in mid winter? Apart from the hardships of the winter climate, winter-hatched chicks are exposed to fire which they would not be if breeding took place in summer. Summer-hatched chicks, however, are exposed to hail. Accurate comparison of the effects of fire and hail upon chick survival is not possible with the data available. Five out of 35 winter-hatched chicks, however, perished in fires, whereas 2 out of 10 summer-hatched chicks died in hailstorms. The detrimental effects of fire and hail thus appear approximately equal.

It is notable that all active wattled crane nests are located in vleis which are neither dry or flooded: water level appears critical. The moat around the nest is an essential feature and the cranes create the moats themselves, or at least contribute towards their formation. A moat can be created very quickly, as was illustrated at Forest Lodge, after the deaths of the male and chick on 31 August 1982. After the arrival of a new male, the female laid in a new nest within the same territory. Initially there was no moat around the nest, but by some assiduous gardening on the part of the cranes it was cleared by hatching time.

The advantage of nesting in winter, the dry season, is that the water level can be relied upon to remain constant. Flooding is thus avoided and the depth and extent of the moat will remain the same throughout the nesting period. Only one nesting attempt was terminated by natural flooding, heavy rain in September 1981 causing the Kildare pair to abandon their nest. Obviously later nesting attempts - i.e., the majority of repeat clutches - will be increasingly subject to the hazard of flooding.

The importance of the water level to successful nesting was demonstrated by events at Blinkwater and Melmoth. At Blinkwater there is no real crane habitat, but the building of a dam created a small marshy area on one bank. Despite the proximity of a wattle plantation, a pair of wattled cranes arrived in 1985 and have since nested. At Melmoth a small dam was built in the catchment area of the main vlei in which two pairs already nested. While not remotely resembling normal nesting habit, the dam nevertheless attracted a new pair of wattled cranes which nested in a totally bare spot in the shallows. A key feature in the nesting success at both localities was the fact that the dams remained full throughout so that water levels were unchanged. Evidently marginal habitat will suffice if sufficiently undisturbed.

It is concluded therefore that the principal advantage of nesting in winter is that maximum security is conferred upon the nest. The winter climate, far from being adverse, provides the stable conditions essential for high nesting success.

Is the Natal wattled crane population distinct from the Transvaal population, and how distinct are South African birds from wattled cranes elsewhere in Africa? Behaviorally several differences exist. South African wattled cranes live in cold areas in permanent sponges and are very sedentary. Even floaters do not stray far outside the breeding range. Elsewhere wattled cranes are semi-nomadic and breed opportunistically. As far as is known, there is no genetic interchange between these two groups.

Within South Africa other differences are notable. Natal birds are much more likely to lay two eggs than Transvaal birds, the difference being highly significant. Natal birds also have a defined, if extended breeding season, whereas Transvaal birds have a fourteen month cycle rather than a conventional season (Tarboton 1984). Do these differences denote genetic separation? The two northernmost Natal pairs nest close to the southern extremity of the Transvaal range. These pairs were discovered late in the study, however, and their nesting data were not used in the Natal analysis. Logically they should be considered part of the Transvaal population. If this is done there is certainly a geographical separation, with a substantial gap between the great majority of Natal breeders and the northern nests near the border with the Transvaal, and little suitable crane country in between. Only individual marking studies will show whether interchange takes place.

Why do wattled cranes only raise one chick even though the second egg is viable and ready to hatch? The purpose of a second egg is presumably to improve the chances of the presence of a fertile egg. Indeed one clutch did consist

of a fertile and an addled egg. Why then discard the second egg when it is so near to hatching? Two reasons are suggested.

First, the second-hatched chick may be much smaller than the first. While the direct evidence for this suggestion consists of a sample of one, other indirect evidence exists. There were four cases of two-egg clutches where the eggs were measured and it was known which one hatched, Table 12. Since weight loss during incubation is linear the heavier egg will produce the heavier chick. In the clutches listed in Table 12 only in one case did the smaller egg hatch and then it differed so little from its nest mate as to be effectively the same size. It is reasonable to conclude therefore that most second hatched chicks would be substantially smaller than average and in general a less viable proposition.

Locality	Egg dimensions (mm)		Weights (g)		First to hatch
			(when first measured)		
Winchester	107.4 × 66.0	100.4 × 61.1	252	203	Larger
Winchester	105.9 × 65.0	100.4 × 63.2	214	190	Larger
Stille Rust	104.5 × 65.4	103.6 × 64.7	208	206	Smaller
Forest Lodge	105.2 × 62.8	99.0 × 58.7	232	189	Larger

**Table 12.** Hatching sequence of C2 wattled crane clutches in Natal in 1980-82.

A second possible reason for abandoning the second egg is that the interval between the hatching of the eggs may be sufficiently long to disrupt normal family life. The first-hatched chick must leave the nest after 1-2 days to find food. It will require at least one parent to keep guard. The egg will require more or less full time incubation, fully occupying the second parent. The Winchester experiment suggests a hatching interval of three days and for this period one parent would have to do the jobs normally shared by both.

The reproductive strategy adopted by the wattled crane can thus be seen as a form of insurance. The extra egg is the insurance, and the premium - the energy required to form it - is low. Once an egg has hatched further insurance - in the form of a second chick of dubious physical capacity - is uneconomical when the premium, the risk to the first-hatched, is greatly raised.

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These speculations concerning the adaptiveness of parental behavior at the time of hatching receive support from a consideration of the sizes of individual eggs.

Since all clutches, of whatever size, never produce more than one chick, and since the productivity of single-egg clutches is about the same as that of two-egg clutches, certain conclusions can be drawn concerning the selective forces molding egg and clutch size.

A large egg is most likely to produce a large viable chick. Not, however, if it is addled. Two-egg clutches provide some insurance against addling, but at the cost of producing a slightly smaller chick. Moreover on average, a two-egg clutch weighs far more (243 + 207 = 450 g) than a one-egg clutch (272 g), with a correspondingly greater outlay of resources. The relationship between egg size and clutch size is thus presumably a function of the conflicting needs to:

1. produce a viable chick
2. economize upon resources.

Wattled cranes showed great readiness to nest again and again in the face of failure. Renesting is a phenomenon widespread in the bird world, and as a general rule clutch size in successive renesting attempts declines as the season progresses, numerous examples being listed by Lack (1954). What is interesting in the present study is that the reverse trend is apparent. Six of the second clutches were the same size as the first while four of them were larger. The sizes of eleven of the first clutches were known and there were three two-egg clutches; average clutch size was 1.27. Of the ten second clutches (two being of unknown size), only three were single-egg clutches; average clutch size was 1.70.

Renesting birds are effectively putting more effort into the latter part of the breeding season than single-clutched pairs. If this is adaptive then at least one, if not all, of the following assumptions must be correct.

1. That adult survival is not, or only slightly affected by nesting.
2. That adequate recruitment to the population demands that adults attempt to breed successfully each season.
3. That the chance of a chick surviving outside the optimal breeding season is reasonably good.

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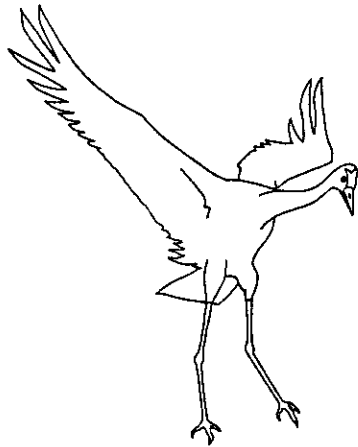
Locality	Egg Weight (g)	Density	Extrapolated Laying Weight	Weight Difference	
Forest Lodge	(1)	232	1.10	232	] 43
	(2)	189	1.09	189	
Tabamhlope		209	0.89	258	
Stadlers Rust	(1)	176	0.88	220	] 34
	(2)	147	0.87	186	
	(1)	210	1.06	218	] 27
	(2)	182	1.05	191	
Yorkville		236	0.95	273	
Winchester	(1)	252	1.06	276	] 67
	(2)	203	1.07	209	
	(1)	214	0.94	250	] 25
	(2)	190	0.93	225	
Stille Rust	(1)	208	0.92	249	] 8
	(2)	206	0.94	241	
Potatoes		203	0.95	235	
Dargavel		234	0.94	274	
Dargle 913		249	0.96	285	
Umgeni Vlei		230	0.96	264	
Kildare	(1)	207	0.93	245	] 45
	(2)	173	0.95	200	
Middle Draai		239	0.95	277	
Elgin	(1)	220	0.96	252	] 39
	(2)	184	0.95	213	
Ideal View		310	0.01	338	
Melmoth		261	1.08	266	
Melmoth Top		235	1.05	246	

Appendix 1. Weights of eggs laid by wattled cranes in Natal in 1980-82.

Locality	Hatching Date	Last Recorded	Outcome
Forest Lodge	?-10-80	1-5-81	Flying, chased away by parents
Forest Lodge	17-6-81	7-10-81	Disappeared, age 3 m
Forest Lodge	?-6-82	31-8-82	Disappeared, age 3 m
Yorkville	10-9-82	31-12-82	Alive
Yorkville	?-10-81	?-5-82	Flying
Winchester	1-7-82	24-8-82	Burnt, age 1 m
Winchester	9-9-82	11-11-82	Alive
Moorgate	20-6-82	31-12-82	Flying
Stille Rust	4-5-82	?-5-82	Dead, age 2 d
Stille Rust	21-6-82	11-11-82	Flying
Dargavel	?-6-81	31-8-81	Burnt, age 2 m
Dargavel	6-6-82	?-9-81	Alive
Kildare	?-7-80	?-9-80	Disappeared, age 2 m
Middle Draai	15-9-81	15-1-82	Flying
Middle Draai	10-8-82	7-10-82	Alive
Burnside	?-10-82	?-5-82	Flying
Burnside	20-9-82	11-11-82	Alive
Midmar	?-7-82	19-8-82	Burnt, age 1 m
Banavie	5-10-80	?-5-81	Flying, left parents
Banavie	1-12-81	18-1-82	Disappeared, age 6 w
Banavie	26-9-82	?-10-82	Alive
Himeville	?-7-80	15-10-80	Disappeared, age 3 m
Himeville	20-5-82	11-11-82	Flying
Castle Dene	1-5-81	?-6-81	Disappeared, age 1 m
Oak Spring	5-6-82	11-11-82	Flying
Dartmoor	12-11-82	28-5-82	Flying
Scawby Bottom	?-7-82	?-8-82	Disappeared, age 1 m
Scawby Bottom	?-10-81	28-5-82	Flying
Scawby Top	16-11-81	28-5-82	Flying
Scawby Top	18-9-82	11-11-82	Alive
Melmoth Bottom	7-9-82	10-9-82	Burnt, age 3 d
Melmoth Top	2-9-82	11-11-82	Alive
Alida Mount	23-7-82	7-10-82	Alive
Hebron	?-12-80	?-5-81	Flying
Twefontein	15-8-81	2-5-82	Flying
Twefontein	23-7-82	11-11-82	Alive, age 3 m
Connemara	24-6-82	?-9-82	Alive, age 2 m
Riversdale	?-5-81	24-7-81	Alive, age 2 m
Marwaqa	?-11-81	3-6-82	Flying
Redlands	27-6-82	5-8-82	Alive, age 1 m
Umvoti Heights	5-8-82	29-9-82	Disappeared, age 1 m
Belmont	?	?-9-79	Burnt
Belmont	?	?-1-80	Killed by hail
Belmont	?-4-81	?-5-81	Disappeared, age 6 w
Reekie Lynn	?-11-80	?-1-81	Killed by bail, age 2 m

Appendix 2. Life histories of 45 wattled crane chicks in Natal in 1980-82.

CHAPTER 12  
NORTH AMERICA





## INTERNATIONAL COOPERATION IN RECOVERY OF WHOOPING CRANES: A MODEL FOR OTHER NATIONS

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### ABSTRACT

Whooping cranes *Grus americana* in 1941 reached one of the lowest population levels of any species that has subsequently shown promise of recovery. Cooperation between Canada, which protects the nesting ground and important fall staging areas, and the United States, which manages the wintering grounds and migration stopovers, has been essential to bring the species back from the brink of extinction. Important cooperative actions began as early as 1916 and provide a model for other nations to follow in restoring their crane species. Actions to recover whooping cranes can be grouped in five categories: (1) administrative, research, and planning activities, (2) protection of the species, (3) protection of the habitat, (4) enhancement of numbers and distribution, and (5) enhancement of habitat. The present world population of about 175 birds and the fledging of 52 wild chicks in the breeding seasons of 1984 through 1986 are encouraging signs that whooping cranes may eventually recover to a safe number and distribution.

Whooping cranes are the most endangered of the world's crane species. In the 20th century they reached one of the lowest population levels experienced by any species that has subsequently shown promise of recovery. In 1941-42 there were only 16 survivors in the migratory flock that wintered on the Texas coast at the Aransas Wildlife Refuge (NWR). From the 16 individuals the flock has slowly grown until in 1986-87 there were 110 birds, including 21 young, in the flock that migrates between Texas and the Northwest Territories of Canada. And from eggs taken from the wild population there are now 40 birds in captivity and a second wild flock in the Rocky Mountains containing about 24 birds.

The primary purpose of this report is to discuss international cooperation that has led to a 10-fold increase in the world population. Early milestones in recovery actions by Canada and the United States sometimes were independent actions not coordinated between the two nations. In the last 40 years, however, recovery actions have been increasingly cooperative and closely coordinated between the two nations. Cooperation between Canada, which protects the nesting ground and important fall staging areas, and the United States, which manages the wintering grounds and migration stopovers, has been essential to bring the species back from the brink of extinction.

### MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act has been described as the most significant piece of protective legislation for whooping cranes (Whooping Crane Recovery Team 1986). This treaty between Great Britain (Canada) and the United States was enacted in 1916 (Table 1). The Act provided a basis for preventing hunting of any migratory species that needed protection. In reality, protection was afforded only

gradually as wildlife enforcement agencies were created and expanded at the Federal, State, and Provincial levels.

**Table 1.** International cooperation that contributed to recovery of the endangered whooping crane, 1916-1987, and future proposed actions.

Year	Action	Result
1916	Migratory Bird Treaty Act.	Prohibited hunting.
1922	Wood Buffalo National Park established.	Protected nesting habitat.
1937	Aransas National Wildlife Refuge established.	Protected key winter habitat.
1945 to 1987	Cooperative research.	Increased knowledge of species.
1967	Transfer of eggs from Canada began to establish a captive flock.	Gave added assurance the species would not become extinct.
1973	Passage of Endangered Species Act in the United States.	Further protected the species and its habitat.
1975	Foster-Parenting Experiment begins.	A second migratory flock is established but not yet breeding.
1976	Recovery Team established in the United States.	Provides guidance to recovery actions.
1978	Critical habitat identified within the United States under the Endangered Species Act.	Improves ability to protect habitat.
1985	Memorandum of Understanding between Canada and the United States.	Defined the recovery role of each nation.

1985	Federal-state cooperative protection of whooping cranes.	Increases the ability to protect the species during migration.
1987	First recovery team formed in Canada and recovery plan published.	Provides added guidance and impetus for recovery actions within Canadian borders.
1990s	Reintroduction efforts proposed to begin at a site to be selected in eastern North America.	Will further increase likelihood of full recovery of the species.
	Second captive flock proposed to be started at a site not yet selected.	Will reduce the likelihood that a disease epidemic could destroy the entire captive flock.

### ESTABLISHING REFUGES

Wood Buffalo National Park, within the Northwest Territories of Canada, was established in 1922 (Table 1). It contains approximately 4.3 million ha of boreal forest and muskeg set aside as a preserve for wood bison *Bison bison athabasca*. The presence of nesting whooping cranes within the vast wilderness park was unknown until 1954. The fortunate action establishing the park assured preservation of nesting habitat and protection from disturbance during nesting activities.

In 1937 the U.S. Fish and Wildlife Service acquired 19,000 ha on the central Texas Gulf Coast to protect whooping cranes and other wildlife (Stevenson and Griffeth 1946; Allen 1952). One of the primary reasons for the purchase was to protect whooping cranes and their winter habitat. It was the only Texas coastal site where Bureau of Biological Survey biologists found whooping cranes in the winter of 1936 (McNulty 1966). This refuge was the November to April home for the migratory whooping cranes that survived in 1941-42. In addition to the refuge, 5,236 ha of adjoining wetland were closed to hunting to provide protection for the birds. The importance of the refuge was not fully realized at the time it was established because the tenuous status of the whooping crane population had not been fully recognized. Along with preservation of the nesting grounds, setting aside Aransas refuge was a key action contributing to the species' survival.

Migration stopover and staging habitat is also protected in the United States and Canada. The foremost area in Canada is Last Mountain Lake Bird Sanctuary established in 1887 in Saskatchewan. Within the United States most of the refuges used by whooping cranes were established during the 1930s through the 1970s for their value as habitat for migratory waterfowl. Some are natural wetlands used by cranes before they became refuges. Others are associated with reservoirs and other artificial wetlands that whooping cranes began using for feeding and roosting along their migration pathway. Most refuges also contain grainfields (corn, wheat, barley, or milo) where ducks, geese, cranes, and other wildlife can feed. Twenty U.S. Federal

refuges in 11 states have received use by migratory whooping cranes.

### RESEARCH ACTIVITIES

The National Audubon Society and the U.S. Fish and Wildlife Service in 1945 began cooperation on an extensive field research project known as the Cooperative Whooping Crane Project. The main objective was to learn about the biology of whooping cranes which at that time were largely birds of mystery. Such information as how long they lived, at what age they began nesting, where they nested, what they ate, their migration pathway, behavior, what types of habitat they needed, and what could be done to protect them and improve their habitat were unknown. The project effectively gathered a core of knowledge about these birds under the leadership of Robert P. Allen of National Audubon Society. This information was published in 1952 as a research report of the Society (Allen 1952). The nesting grounds were discovered in 1954 and the habitat studied in 1955 (Allen 1956).

In 1956 the Cooperative Whooping Crane Project, having accomplished many of its goals, was replaced by a committee called the Whooping Crane Advisory Group. It included about a dozen members of various conservation agencies. Its purpose was to identify and study problems facing the whooping crane and to make management recommendations to the U.S. Fish and Wildlife Service.

In the 1960s Canada began long-term biological studies on the nesting grounds that have since greatly expanded our understanding of these beautiful birds (Novakowski 1966; Kuyt 1981; Kuyt and Goossen 1987). In 1982 through 1984 the two nations cooperated in radio-tracking studies of migration. Final reports for this project are being prepared for publication with Dr. Marshall Howe of the U.S. Fish and Wildlife Service writing observations of on-ground behavior and habitat analysis and Ernie Kuyt of the Canadian Wildlife Service reporting the aerial tracking portion.

### THE CAPTIVE FLOCK

Beginning in the mid-1950s various individuals and groups proposed establishing a captive flock to diminish the likelihood of extinction of the species if some natural disaster decimated the remnant wild flock. Captive propagation also would permit research on some aspects of crane biology that were impractical in the wild. The ultimate goal of such propagation would be to provide eggs or birds that could be placed back into the wild to start new populations or to augment existing flocks.

Biologists had noted that whooping cranes normally laid two eggs but seldom were successful in raising more than one chick. Dr. Ray Erickson, of the U.S. Fish and Wildlife Service, postulated that one egg might be removed from each two-egg clutch without adversely affecting the wild population. The removed eggs could provide the origin of a captive flock and would result in a net increase in total population.

Sandhill cranes *Grus canadensis* were used as the surrogate research species to develop egg-removal procedures



and propagation methods. This activity began in 1961 with approval of the Whooping Crane Advisory Group. In 1967 the Canadian Wildlife Service and the U.S. Fish and Wildlife Service began gathering whooping crane eggs in Canada for shipment to Patuxent Wildlife Research Center where the permanent propagation facility was located near Laurel, Maryland. Fifty eggs were transferred by 1974 and 15 eggs in the 1980s. Fifty of the total of 65 eggs hatched and 30 chicks fledged.

Egg production by captive females began in 1975. By 1986, 197 eggs had been produced at Patuxent: 147 were fertile, 110 hatched, and 45 fledged. Seventy-three of the eggs were transferred to the cross-fostering experiment discussed later in this paper. There are now 38 whooping cranes at Patuxent including 5 pairs that have successfully reproduced and 9 newly-formed pairs that should begin egg production in the next two to three years.

#### ENDANGERED SPECIES ACT

In 1973, the U.S. Congress passed the Endangered Species Act which provided added legal protection to whooping cranes which were listed as an endangered species. The purposes of the Act are to conserve species and the ecosystems upon which endangered and threatened species depend, to provide a program for conservation of such species, and to achieve purposes of treaties and conventions such as the Migratory Bird Treaty Acts with Canada and Mexico.

The Act prohibits "taking" of any endangered species except by a special permit. To take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Anyone convicted of criminal violation of the Act will be fined not more than \$20,000 or imprisoned for not more than one year, or both. The Secretary of the U.S. Treasury is authorized to pay a reward equal to one-half of the civil penalty paid, but not to exceed \$2,500, to any person who furnishes information that leads to a conviction.

The Act also recognizes the need to conserve critical habitat containing physical or biological features essential to conservation of the species. In 1978, the U.S. Fish and Wildlife Service officially designated two wintering sites, six migration stopovers, and one summer range as critical habitat within the contiguous United States (Whooping Crane Recovery Team 1986: Appendix D). This action increases the likelihood these areas will be protected. Each U.S. Federal agency must ensure that an action funded, authorized, or carried out by them is unlikely to result in destruction of or adversely modify critical habitat.

The Endangered Species Act instructs the Secretary of Interior to develop and implement recovery plans for conservation and survival of endangered species. The Secretary may procure services of qualified persons, organized as a team, to develop the recovery plan. The first whooping crane recovery team in the U.S., appointed in 1976, included representatives from National Audubon Society, two states, the U.S. Fish and Wildlife Service, and the University of Idaho. Each team member had expertise on cranes, endangered species, or management of migratory birds. The

first recovery plan was published in 1980 and revised in 1986. The team continues to function as an advisory group. Canada lacks Federal legislation similar to the Endangered Species Act but formed a team in 1987 and published a plan which emphasizes recovery activities within their national boundary (Cooch et al. 1987).

#### THE CROSS-FOSTERING EXPERIMENT

The restricted breeding and wintering distribution of the wild population continued to be a concern of conservationists despite establishment of the captive flock. Fred Bard, then Director of the Saskatchewan Museum of Natural History, had earlier proposed cross-fostering whooping cranes to sandhill crane parents as a means of starting a breeding population at a second site. As preparation for such an effort, Drs. Roderick Drewien and Elwood Bizeau of the University of Idaho intensively studied the sandhill crane population at Grays Lake NWR from 1969 to 1974 (Drewien and Bizeau 1974). They then submitted a proposal to test cross-fostering at Grays Lake. The experiment was approved by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service in 1974.

Egg transfers from Wood Buffalo National Park began in 1975. Since then 275 eggs have been transplanted to sandhill crane nests: 187 eggs hatched, and 80 chicks fledged. A minimum of 21 whooping cranes now survive in this new flock that summers in Idaho, Wyoming, Montana, and Utah and winters in New Mexico, Arizona, and Mexico. Although some pairing behavior has been observed, no breeding has occurred. The cross-fostering project is continuing and will be reviewed in 1989.

#### MEMORANDUM OF UNDERSTANDING

For several decades Canada and the United States worked cooperatively on recovery actions without formal, detailed guidelines for their cooperation. The cooperative recovery roles were more officially recognized in 1985 in a Memorandum of Understanding (MOU). "The purpose of this memorandum is to clarify and document existing arrangements and understandings to improve the coordination of, and joint cooperation in, Whooping Crane management and conservation programs, and research activities undertaken by the United States and Canada." (Whooping Crane Recovery Team 1986: Appendix E). The signators are the Director-General of the Canadian Wildlife Service and the Director of the U.S. Fish and Wildlife Service.

The MOU states that all eggs and resulting progeny from the breeding grounds and captive breeding will remain under common stewardship of both nations. The agencies will share in decisions about birds, eggs, and parts thereof, whether alive or dead. The memorandum discusses the subjects of population restoration, population objectives, experimental cross-fostering, new population sites, international management, and recovery plans.

Each agency appointed one person and an alternate to coordinate day-to-day implementation of this MOU. Dr. F. Graham Cooch was appointed Whooping Crane Coordinator

for the Canadian Wildlife Service. The author was appointed to a similar position for the U.S. Fish and Wildlife Service. The establishment of these central contact points for information exchange and decisions has facilitated implementation of recovery activities. Each coordinator is a member of the other nation's recovery team.

#### FEDERAL-STATE COOPERATIVE PROTECTION

Studies of mortality within the self-sustaining wild population indicate the greatest losses probably occur during the 4000 km migration in spring and fall. A known cause of losses during these flights is collision with powerlines. A potential loss is accidental shooting by hunters who mistakenly identify whooping cranes as legally hunted species. Among the so-called look alike species, those appearing somewhat similar to whooping cranes are snow geese *Chen caerulescens* and sandhill cranes. Waterfowl and sandhill crane hunting activities in the fall months coincide with the whooping crane migration.

In 1985 a plan was developed which would reduce the likelihood of accidental shooting of whooping cranes. It also is designed to increase the chance for quick recovery and treatment of sick or injured birds. Called the "Contingency Plan For Federal-State Cooperative Protection of Whooping Cranes" (Whooping Crane Recovery Team 1986: Appendix F), the plan was approved by directors of 13 state wildlife agencies and by the U.S. Fish and Wildlife Service. Two state and two Federal employees in each state are assigned to implement the plan. Sighting reports of whooping cranes are relayed to those individuals and efforts made to determine if the sightings are valid.

If the presence of whooping cranes is confirmed they are observed to see if they are healthy, sick, injured, in a contaminant spill area, in a hazardous hunting zone, or at a site with a chronic avian cholera problem. The observer's response will vary in each circumstance. As an example, when a whooping crane is in an area of intensive bird hunting activity which the responsible employee believes may be hazardous to the crane, several square miles may be closed to hunting activity until the crane or cranes depart. Such action has been taken at sites in Kansas and Colorado. The Contingency plan has now become a part of the Memorandum of Understanding and is also followed in response to the presence of whooping cranes in the Canadian Provinces.

An important aspect of the plan is conservation education efforts to promote public awareness of the species' endangered status and to teach the identification features that characterize whooping cranes. As public awareness improves, two results are anticipated. First, there should be an increase in reported sightings of whooping cranes. That increase will improve the ability of governmental agencies to protect these birds. Second, an informed hunting public is less likely to shoot a whooping crane by mistake.

#### EGG EXCHANGES WITHIN CANADA

In 1985, the whooping crane coordinators of Canada and the United States decided to try to increase chick produc-

tion within Wood Buffalo National Park. Field personnel then began floating eggs at the time of egg pickup to determine if they were viable. This was done because a few pairs had a history of producing infertile eggs. In the past three years such infertile eggs have been removed and a single fertile egg substituted from another nest. In 1986, this exchange occurred in three nests and one of the pairs successfully raised its chick (Ernie Kuyt pers. comm.).

#### PLANS FOR THE 1990s

In October 1984, studies began at three sites in eastern North America that were considered potentially suitable for establishing a third wild flock of whooping cranes. Project personnel will complete reports evaluating each site late in 1987. The advantages and disadvantages of each site will be compared and the two nations will select the favored site in 1988 or 1989. The study sites are the upper peninsula of Michigan and adjacent Ontario, Canada; Okefenokee Swamp in southern Georgia; and several areas in central Florida.

The Michigan site is populated with greater sandhill cranes *Grus canadensis tabida*, which migrate to Florida in winter. Introducing whooping cranes at this site would require use of the cross-fostering technique. The site's potential is dependent on success of the cross-fostering experiment at Grays Lake NWR. The Georgia and Florida sites contain nesting populations of Florida sandhill cranes *G. c. pratensis*. These cranes are nonmigratory and whooping cranes would be reestablished at these sites using the gentle release technique. This technique has been successful in bolstering populations of the endangered Mississippi sandhill crane *G. c. pulla* (Valentine and Logan this proceedings).

The second major event proposed for the 1990s involves establishing a second captive flock. Since the first captive flock was established, a goal has been to develop a second captive flock when the first flock reached a level of 10 to 15 breeding pairs. A second flock would reduce the likelihood that all captive birds might die in a disease epizootic. The breeding pair goal of the existing captive flock is likely to be reached in the next two years. The two nations are now evaluating where the second captive flock should be housed.

#### DISCUSSION

What general conclusions can be drawn from this review of cooperative international actions that have brought this species back from the brink of extinction? And what can other nations gain from Canadian and U.S. experiences that can be applied to recovery of their endangered wildlife species?

Actions to recover whooping cranes can be grouped in five categories: (1) administrative, research, and planning activities, (2) protection of the species, (3) protection of the habitat, (4) enhancement of numbers and distribution, and (5) enhancement of habitat. These are listed in the sequence they logically will occur.

These same five categories of recovery actions would be applicable for recovering any endangered crane species. A basic requirement for an effective recovery program is information on the species' biology, where it nests, winters, its migration pathway, migration stopover sites, and what hazards it faces. If such information is lacking, biological research activities become an integral part of the recovery process. But if some key information is lacking, such as knowledge of the nesting ground location, it is necessary to take all practical recovery actions without waiting until the biological information is complete.

A recovery team should be organized, comprised of individuals knowledgeable about the species and related topics such as wetland management. Their role is to aid in developing a plan that will identify recovery needs and place priorities on actions. The team membership should, preferably, be representative of the bird's distribution. If the species occurs in several nations, then the recovery team should ideally have a similar multinational composition.

A Memorandum of Understanding, or some similar legal administrative document, is useful in describing actions that cooperating nations will endeavor to accomplish. And the appointment of one person as species coordinator in each nation will help maintain the impetus of recovery. This individual also becomes a focal point for coordinating cooperative recovery actions with other nations.

Protection of a species and its habitat are essential first steps to recovery. Actions directed primarily at protecting whooping cranes include the Migratory Bird Treaty Act,

portions of the Endangered Species Act, and the Contingency Plan For Cooperative Protection of Whooping Cranes. Actions directed principally at protecting habitat, but also protecting the birds, include establishing refuges and designation of critical habitat under the U.S. Endangered Species Act.

Categories 4 and 5, enhancement of numbers and of habitat, require a good understanding of the species' biology before they can be initiated. They are a more intensive form of recovery. For whooping cranes, the enhancement of numbers and distribution includes developing the captive flock, starting additional wild populations, and the egg exchanges within Wood Buffalo National Park. Enhancement of habitat is a recovery category that includes management of upland habitat on the wintering grounds (Slack and Hunt 1967), improvement of roosting habitat along the Platte River, Nebraska (Currier and Ziewitz 1987), and management of feeding fields on refuges (Kauffeld 1982).

The present world population of about 174 whooping cranes, the production of 52 fledging-age chicks in the past three breeding seasons, and the recent increase in pairs in the wild and captivity, are encouraging signs that this species may eventually recover to a safe number and distribution. Much remains to be done, however, and decades will pass before recovery is complete. But the accomplishments of this century are sufficient to provide guidelines that other nations may use in recovering their endangered crane species to safe numbers.

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## THE MIGRATION ECOLOGY OF WHOOPING CRANES IN NEBRASKA, U.S.A.

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### ABSTRACT

Nebraska is an important migration stopover for the wild flock of whooping cranes *Grus americana*. The ecology of this species on the winter and nesting grounds has been studied extensively; migration ecology, however, is poorly known. We studied habitat use and behavior of whooping cranes in Nebraska during their spring and fall migration periods. Activity budget data were collected from 1984 through 1986; site evaluations were dated from 1977 to 1986. We collected 100.7 bird-hours of activity budget data and reviewed site evaluation forms summarizing 74 confirmed sightings within the state. Comparisons were made between spring and fall sightings as well as between family and non-family groups. Wetlands, both riverine and palustrine, appear to be the most important habitat component for whooping cranes in Nebraska. Our findings provide resource managers with information vital to the future management of this endangered species.

### INTRODUCTION

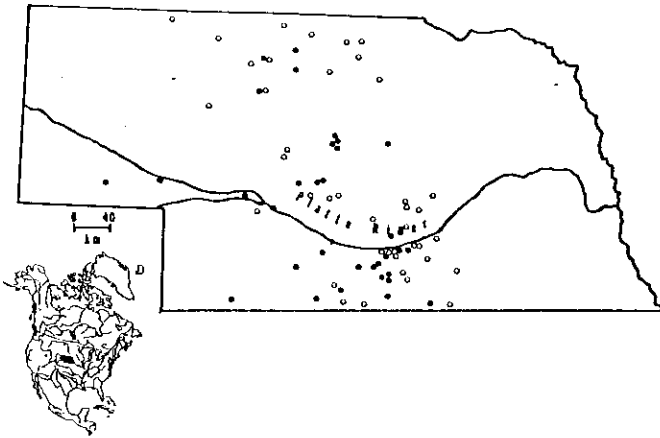
The ecology of the wild flock of whooping cranes, which is restricted to North America, has been studied on their wintering grounds in Texas (Allen 1952; Blankinship 1976; Bishop 1984) and their nesting grounds in the Northwest Territories of Canada (Allen 1956; Novakowski 1966; Kuyt and Goossen 1987). But there is little quantitative information available on habitat use during migration (Johnson and Temple 1980; Lingle et al. 1984, 1986). Howe (1987) recently described habitat use by 18 radio-marked whooping cranes in their 2400-mile (3865 km) migration corridor during three southbound and two northbound migrations. Nebraska, especially the area near the Platte River in the southcentral portion of the state, is an important migration stopover (Swenk 1933; Brooking 1943; Allen 1952; Johnsgard and Redfield 1977; U.S. Fish and Wildlife Service 1986; Lingle 1987). The Platte River's central location between the cranes' wintering and nesting grounds, and the river's abundant wetland complexes, especially prior to 1940 (Currier et al. 1985), regularly attract whooping cranes. Dates of occurrence in Nebraska in spring are from late March to early May with a peak in early April, and in fall from late September to early November with a peak in late October. This paper focuses on whooping crane migration ecology in Nebraska.

### STUDY AREA AND METHODS

We reviewed site evaluation data of confirmed whooping crane sightings throughout their migration corridor within the state (Figure 1) and collected activity budget data primarily from southcentral Nebraska. Site evaluation information has been collected by the Nebraska Game and Parks Commission at areas used by Whooping Cranes since 1977. Daily movements and habitat use were recorded on the evaluations. Specific habitat-types were lumped into general habitat categories (Table 1). These data were collected through continuous surveillance of the cranes, through on-site inspection of areas used, and from interviews with persons sighting cranes. The data indicate the amount of time cranes spent in a particular habitat type. Diurnal habitat use was defined as the period between sunrise and sunset. Extreme observation dates were 29 March to 9 May during spring and 7 October to 22 November during fall.

For most sightings, the exact time of arrival and duration of stay were not known. Several sightings included nights where the actual roost location was not known. The following criteria were used to determine length of stay and habitat use. A known overnight stay included nights between initial and final sightings of groups as well as nights when an observation was made until dusk, at dawn,

or between dusk and dawn. An assumed overnight stay was when the initial sighting occurred after dawn but within two hours after sunrise or if the only observation occurred between sunset and dusk.



**Figure 1.** Map of Nebraska showing the location of confirmed whooping crane sightings from fall 1977 to fall 1986 (N=74). The solid circles are spring sightings (N=33) and the open circles are fall sightings (N=41).

CROPLAND <sup>a</sup>	WETLAND	GRASSLAND
Corn stubble	Natural wetland	Upland grassland
Wheat stubble	Tilled wetland	Lowland grassland
Milo/sorghum stubble	Riverine	Alfalfa
Soybean stubble	Stockdam	
Winter wheat	Reservoir	
Rye		
Fallow		

**Table 1.** Habitat types included in the general habitat categories.

<sup>a</sup>We noted whether grain stubble was disced or grazed if known.

We considered the habitat of night roosts to be known if the cranes were observed in a wetland at or between dusk and dawn. Assumed roost types were assigned only if three conditions were met: 1) cranes were observed in or near [less than 2 mi (3.2 km)] a wetland within two hours of sunrise or sunset, 2) use of that wetland was confirmed by tracks or a subsequent observation, and 3) no other wetland types occurred in proximity to the crane's use area. Otherwise, the roost type was considered unknown. To quantify habitat use for assumed overnight stays and roost types, we assigned time periods to habitat categories as follows. When the roost type was unknown, the entire period from sunset until the initial sighting time was assigned to the unknown habitat category. If a roost type was assumed or known, the period from sunset to sunrise was assigned to that roost type. The period from sunrise to initial sighting was also assigned to that roost type if the initial sighting occurred in the roost, but was assigned to the unknown category if the initial sighting occurred away from the roost. When the initial sighting occurred before sunrise or after sunset, times were adjusted according to actual observations. We compared seasonal habitat use

(spring versus fall) as well as habitat use of family and non-family groups. Family groups were defined as those groups consisting of one chick and one or both parents while non-family groups contained all other combinations of birds. Sightings with both family and non-family components were separated into their respective groups.

Activity budget data were collected on a single crane or simultaneously on groups of up to three cranes. Continuous observation periods ranged from 20 minutes to two hours with a desired goal of at least one hour. Behavior was recorded according to the categories in Table 2, which are similar to those used by Howe (1987). In most cases, two people collected the data. One person kept track of time and recorded the behavior codes while the other person made observations through a 25x spotting scope. On six occasions, a single observer collected data using an audible timer that beeped at 10-second intervals. Behavior codes were recorded with a cassette tape recorder. The date, time, and habitat type that cranes used were recorded for each observation period. We also recorded age, whether individuals were banded, and whether individuals were part of a family group.

<b>Category "No data"</b>	<b>Category "Feeding"</b>
Bird out of view	Feeding
Other cause for no data	Adult feeding juvenile
	Drinking
<b>Category "Locomotion"</b>	Other feeding
Stand	
Stand in alert position	<b>Category "Comfort"</b>
Walk	Preen
Fly	Sleep
Other locomotion	Bathe
	Other comfort
<b>Category "Interaction"</b>	<b>Category "Vocalizations"</b>
Threat	Unison call
Submission	Alarm call
Fight	Other vocalization
Dance	
Other interaction	

**Table 2.** Behavior categories used for collection of activity budget data.

During observations, a crane would occasionally wander out of view, or for some other reason a crane's behavior could not be determined, and a "no data" behavior category was recorded. When a crane flew, a behavior category for flight was recorded, but a habitat type could not be recorded. A total of 3.0 bird-hours of observations was collected under these circumstances and were excluded from the analyses.

We collected 100.7 bird-hours of activity budget data at four observation time intervals: 24.0 bird-hours at 10-second, 52.6 at 12-second, 4.0 at 15-second, and 20.1 at 30-second intervals. Because data taken at different observation intervals must be transformed to a common interval for analysis, we examined the feasibility of transforming the 12-, 15-, and 30-second observations to a common interval of 10 seconds. We subsampled the two largest activity budget samples, the 10- and 12-second observations, taking every third datum to create data sets

	# BIRD-HOURS				# HOURS				N
	Total	Mean	SD <sup>a</sup>	Range	Total	Mean	SD	Range	
SPRING	3889	134	190	1 to 984	1590	55	93	<1 to 492	29
Family	1165	116	104	33 to 253	388	39	35	11 to 118	10
Non-family	2724	143	225	1 to 984	1202	63	113	<1 to 492	19
FALL	3847	99	176	<1 to 934	1449	37	60	<1 to 311	39
Family	2728	170	258	41 to 934	939	59	86	14 to 311	16
Non-family	1120	49	40	<1 to 175	510	22	22	<1 to 88	23
TOTAL	7737	114	182	<1 to 984	3040	45	76	<1 to 492	68

**Table 3.** Length of stay of whooping cranes by season and by family versus non-family groups.

<sup>a</sup>SD=standard deviation.

equivalent to 30- and 36-second observations, respectively. We tested the null hypothesis that the distributions of the original samples and their subsamples were identical using a chi-square test.

The 10- and 30-second data were very similar ( $p > 0.99$ ). Threat behavior, which occurred twice in the 10-second data, did not occur in the 30-second subsample. The 12- and 36-second data were also very similar ( $p > 0.99$ ), with all behaviors occurring in both data sets. Based on these results, we transformed all data to 10-second-equivalent observations. The 30-second data were multiplied by 3.0, the 15-second by 1.5, and the 12-second by 1.2 to obtain 10-second-equivalent data.

Activity budget data were analyzed as frequency distributions of the behavior categories. We compared behavior in wetlands versus croplands, in family groups versus non-family groups, and in spring versus fall migrations. We tested the null hypothesis that the frequency distributions in these paired subsets were identical using chi-square test.

## RESULTS

### Site Evaluations

**Length of stay**—The length of stay was calculated from 68 confirmed sightings involving 193 individual whooping cranes (Table 3). We did not include radio-tagged cranes in this analysis. Length of stay was highly variable thus data in Table 3 should be used with caution. A total of 3040 hours were recorded from groups ranging in size from one to seven cranes. Individual sightings ranged from less than 1 to 492 hours with the longest stay recorded by a non-family group. Family group stays totaled 1327 hours (3893 bird-hours); non-family groups totaled 1712 hours (3844 bird-hours).

Thirty percent of the spring habitat use based on bird-hours was by family groups as compared to 70% spring use by non-family groups. This difference is probably due to the greater number of visits by non-family groups. In contrast, 71% of the fall use was by family groups (Table 3). This was due to a greater length of stay per visit by family groups. A similar relationship appears when the number of hours are examined; family groups made up 24 and 65% of the spring and fall use respectively. The longest known stay of two or more cranes was in spring 1984 when two 2-year old individuals spent 22 days adjacent to the North

Platte River near Hershey, Nebraska. Both birds were radio-tagged.

**Diurnal habitat use**—Diurnal habitat use was described from 51 confirmed sightings. Of the 2280 bird-hours of use, 1527 bird-hours (67%) were in known habitat types. Corn stubble received the greatest use (37%) followed by tilled wetlands (18%) and natural wetlands (17%) (Table 4). When the habitat types were lumped according to groups, 53% of the use was in uplands and 47% was in wetlands.

Habitat Type	Bird-hours	Percent
Corn stubble	559	37
Winter wheat	102	7
Grassland <sup>a</sup>	79	5
Fallow	36	2
Small grain <sup>b</sup>	32	2
<b>Total for UPLAND</b>	<b>808</b>	<b>53</b>
Tilled wetland	277	18
Natural wetland	261	17
Stock dam	97	6
Riverine	61	4
Reservoir	23	2
<b>Total for WETLAND</b>	<b>719</b>	<b>47</b>

**Table 4.** Diurnal habitat use by whooping cranes based on site evaluations (N = 1527 bird-hours).

<sup>a</sup>Also includes rye and alfalfa

<sup>b</sup>Includes wheat, soybean, and milo/sorghum stubble.

Habitat use varied by season with greater use of wetlands and grasslands in the fall and greater use of croplands in the spring (Figure 2). Within season use was greatest for croplands in spring (57%) and greatest for wetlands in fall (51%). We believe this resulted from the proportionally greater fall use of wetlands and grasslands by non-family groups and of croplands by family groups (Figure 3). Spring habitat use was similar among family and non-family groups (Figure 4).

**Nocturnal habitat use**—We examined 313 bird-nights of use from 54 confirmed sightings for which nocturnal roosting habitat was known or assumed. Wetlands were used for roosting in all cases. Natural wetlands accounted for 45% (141 bird-nights) of the bird-nights followed by tilled wetlands with 23% (Figure 5). Reservoirs made up only 2% (6 bird-nights) of the total.

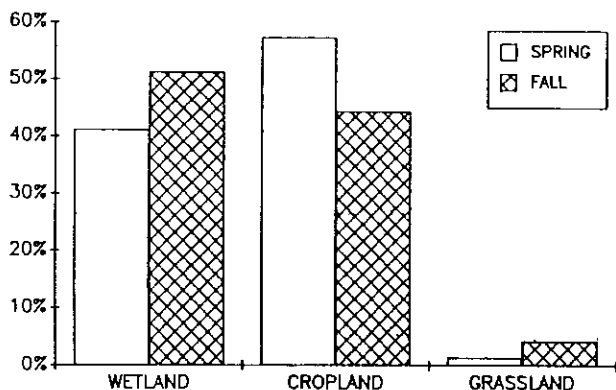


Figure 2. Diurnal habitat use by season (based on 1527 bird-hours in known habitats).

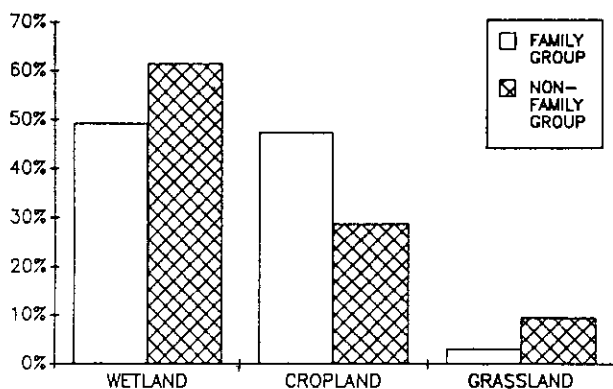


Figure 3. Diurnal habitat use by family and non-family groups during fall (based on 890 bird-hours in known habitats).

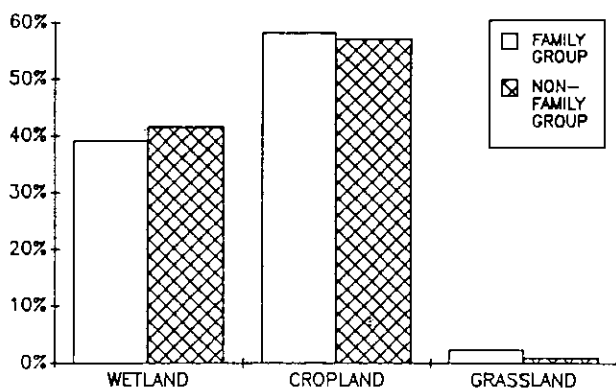


Figure 4. Diurnal habitat use by family and non-family groups during spring (based on 636 bird-hours in known habitats).

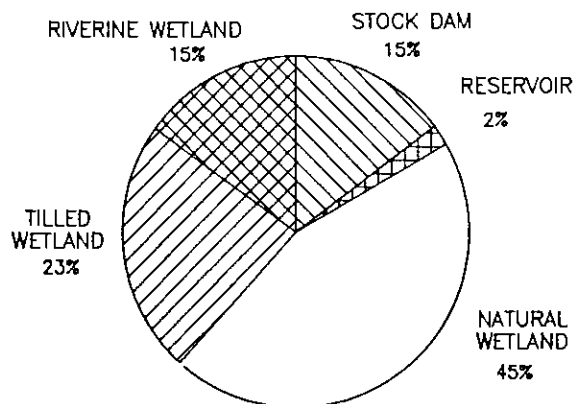


Figure 5. Distribution of roost habitat types based on 313 bird-nights.

For the five roost habitats, family groups showed a relatively greater use of tilled wetlands, stock dams, and reservoirs while non-family groups had greater use of natural and riverine wetlands (Figure 6). Seasonal use of roost habitats was greater in spring for tilled and natural wetlands while the other roost types had a greater fall use (Figure 7). About 75% of the spring non-family groups roosted in natural wetlands. About 77% of the spring family groups roosted in natural and tilled wetlands. There were no records of reservoir use in the spring. The greatest use by non-family groups in the fall was of riverine wetlands (52%) followed by natural wetlands and stock dams (24% each). Fall family groups used natural and tilled wetlands the most (68%) with stock dams comprising 21% of the bird-nights. Reservoirs and riverine wetlands accounted for six bird-nights each for 10% of the known fall family group use.

#### Activity Budget

Duration of observations in wetlands versus croplands, family groups versus non-family groups, and spring versus fall are shown in Table 5. Most observations were of non-family groups in croplands in the spring (47.5 bird-hours or 49%). Of the 32.3 bird-hours collected in wetlands, 18.6 hours were in natural wetlands, 8.1 were in tilled wetlands, and 5.6 were in stock dams. All of the fall observations were collected from a single family group.

The frequency distribution of behavior among wetland types was significantly different from behavior among croplands ( $p < 0.01$ , Figure 8). About one third of the observations in both wetlands and croplands were of cranes feeding (33 and 32%, respectively), but cranes spent more time in comfort and interaction behaviors in wetlands than in croplands (27 versus 10% and 2 versus 1%, respectively), and less time in locomotion behaviors (38 versus 57%).

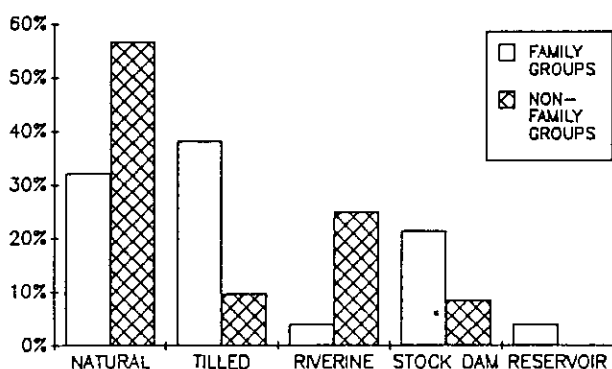
The frequency distribution of behavior for family groups was significantly different from the distribution for non-family groups ( $p < 0.01$ , Figure 9). One half of the family group observations were of cranes feeding, compared to 22% of non-family group observations. Family groups spent



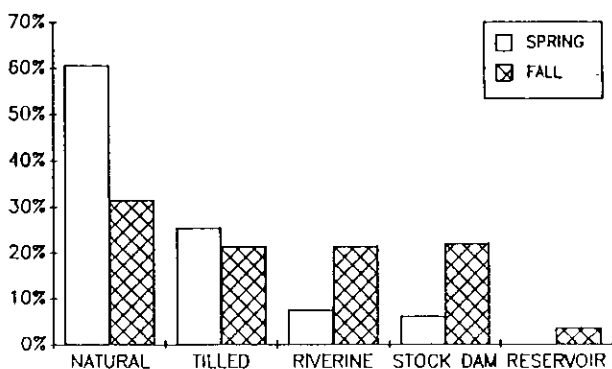
less time in locomotion and comfort behaviors than did non-family groups (38 versus 58% and 11 versus 18%, respectively), and slightly more time in interaction behaviors (2 versus 1%).

Habitat	Family or Non-family Group	Season	Bird-hours
Wetland			32.3
	Family	Spring	12.1
		Fall	5.6
	Non-family	Spring	14.6
Fall		0	
Cropland			65.4
	Family	Spring	9.6
		Fall	8.3
	Non-family	Spring	47.5
Fall		0	
Total			97.7

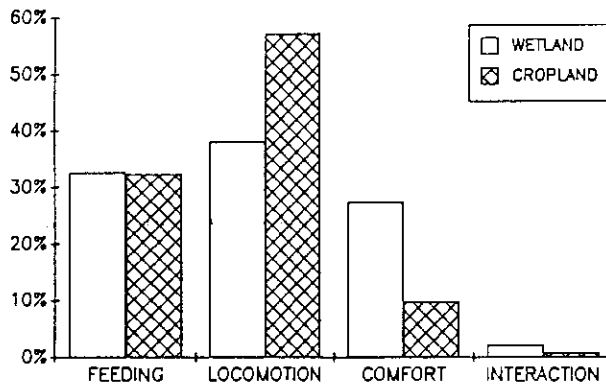
**Table 5.** Duration of activity budget observations (excluding observations where a behavior or habitat type could not be recorded).



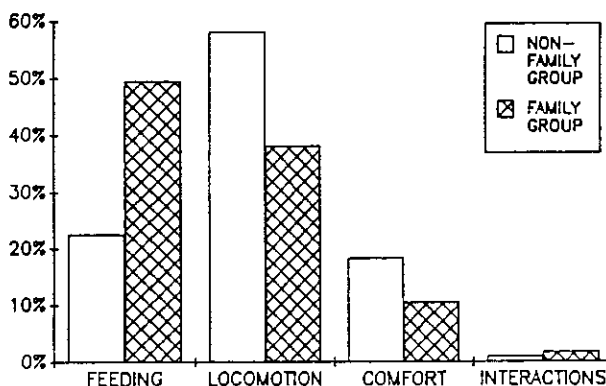
**Figure 6.** Whooping crane roost types by family and non-family groups.



**Figure 7.** Whooping crane roost types by season.



**Figure 8.** Frequency distribution of behavior for whooping cranes observed in wetlands (N = 32.3 bird-hours) versus croplands (N = 65.4 bird-hours).



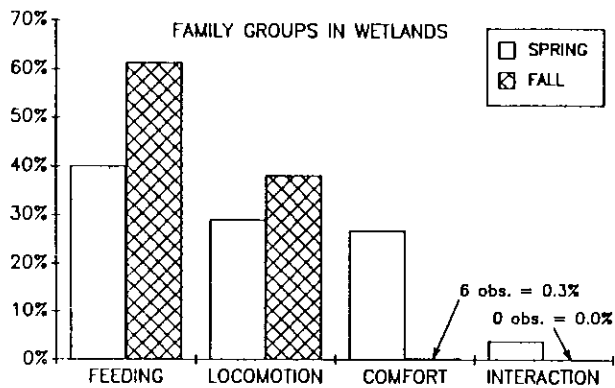
**Figure 9.** Frequency distribution of behavior for family groups (N = 35.6 bird-hours) versus non-family groups (N = 62.1 bird-hours).

Because our fall observations were of a single family group, we compared the spring versus fall behavior of family groups only. In both wetlands and croplands, the frequency distribution of behavior in spring was significantly different from fall behavior (in wetlands,  $p < 0.01$ , Figure 10; in croplands,  $p < 0.01$ , Figure 11). The most notable difference was behavior in wetlands; cranes spent a much greater percentage of their time feeding in the fall (62 versus 40%), and a much greater percentage of their time engaged in comfort movements in the spring (27 versus <1%). In croplands, more time was spent in feeding and comfort behavior in spring (61 versus 49%), while locomotion was more prominent in fall (39 versus 50%).

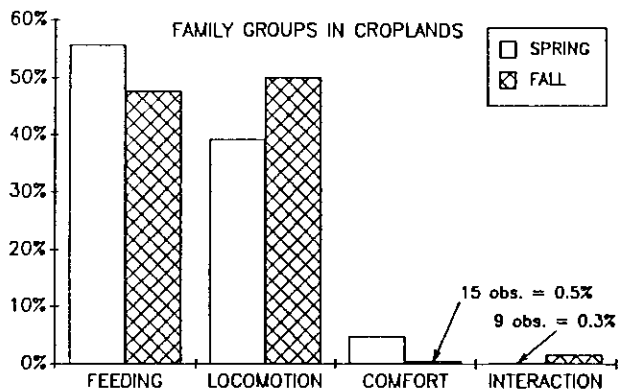
**CONCLUSIONS**

Our data reveal that family groups of whooping cranes spend more time in Nebraska during their fall migration than do non-family groups. The reverse is true in the spring when non-family groups have longer stays. A biological hypothesis for this observation is that during the spring

migration, successful nesting adults from the previous year have to return to their nesting territories to reproduce during a short nesting season. Chicks accompanying these birds would be nearly one year old and would have acquired the strength and stamina to remain with their parents on the northward migration. Family bonds are generally severed in Saskatchewan, Canada, as evidenced by the radio-telemetry study (U.S. Fish and Wildlife Service, unpublished data). Non-family groups generally consist of sub-adult individuals. These birds are not pressured to head north in order to nest, and thus their spring migration is more leisurely. On the southbound migration, family groups include a chick that is less than six months of age. These



**Figure 10.** Frequency distribution of behavior for family groups in wetlands during spring (N = 12.1 bird-hours) versus fall (N = 5.6 bird-hours).



**Figure 11.** Frequency distribution of behavior for family groups in croplands during spring (N = 9.6 bird-hours) versus fall (N = 8.3 bird-hours).

chicks are unaccustomed to the rigors of migration, and the parents migrate at a much slower pace for the chick's benefit. Also, it is not as urgent for the adults to reach the wintering grounds as it is for them to reach the nesting grounds. Non-family groups contain individuals that have experienced one or more round-trip migrations, and thus they spend less time in Nebraska.

Diurnal activities were always in proximity to wetlands. Wetlands provided a source of drinking water, aquatic food, and loafing habitat. During wet weather, whooping cranes would drink from small puddles in croplands; wetland habitats, however, were visited daily during daylight hours. Croplands and upland grasslands are not limiting throughout the majority of the area in their migration corridor in Nebraska. Nocturnal roosts were always in a wetland.

Based on the percent use, natural wetlands may be preferred over tilled wetlands, especially in the spring (Figure 7). If tilled and natural wetlands were selected based on availability, then we would expect higher percent use of tilled wetlands since they are more abundant. This is especially true since over 90% of the natural wetlands occurring in southcentral Nebraska have been drained, making ephemeral sheetwater areas in tilled wetlands more available (Lingle 1987). In spring, however, natural wetland roost sites have about 2.4 times as many bird-nights as tilled wetlands and 1.4 times as many in the fall. The richer biota found in natural wetlands may attract whooping cranes to these sites. We believe that the availability of an adequate wetland complex is the most important factor limiting occurrence of whooping cranes and the extent of their stay in Nebraska.

The behavior of whooping cranes in wetlands as compared to croplands confirms the importance of wetlands for comfort activities and social interactions. About an equal proportion of time is spent feeding in both habitats. Locomotion is most prominent in croplands, undoubtedly the result of the cranes' behavior of walking while foraging in fields. Family groups spend more time feeding than do non-family groups, probably due to the presence of a chick. The fact that family groups spend more time feeding in wetlands in fall as compared to spring may be due to the prior foraging experience of the chicks; wetlands provide the only foraging habitat on the nesting grounds and that is where hatch-year chicks are accustomed to feeding. Also, the chick may require particular animal proteins that may occur only in wetlands. Aquatic habitats are primary foraging areas on the wintering grounds as well. Cropland habitats are used more during migration, and the older, more experienced birds exploit these areas.

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## RECLAMATION OF CRANE ROOSTING HABITAT ON THE PLATTE RIVER AND RESTORATION OF RIVERINE WETLANDS

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### ABSTRACT

Major changes have occurred along the Platte River in Nebraska since water diversion began in the 1860s. Historically the Platte was a mile or more wide and characterized by an unvegetated streambed bordered by prairie grasses and wetlands. With reduced peak flows, the channel narrowed, and woody vegetation became established over much of the former floodplain. Channel area has been reduced 50% to 85%. Channel width has been reduced even further, resulting in a loss of up to 97% of the roosting habitat for sandhill cranes *Grus canadensis* and whooping cranes *Grus americana*. In 1982, the Platte River Trust began a habitat rehabilitation and restoration program to maintain migratory bird habitat. In this paper, efforts to maintain roost sites and to recreate wetlands are discussed. A variety of experimental techniques have been used to clear trees and shrubs. The most effective method has been to clear woody islands and sandbars by shredding, followed by disking. Herbicides have been effective, but there is concern about their widespread application. The Trust has maintained about 25 km of river channel as roost habitat. In 1984, a project was started to restore wetlands adjacent to the active river channel. Cottonwoods were removed from a 160 ha tract. Fire, herbicides, and grazing will be used experimentally to control regrowth of woody species. Water control structures will maintain wetlands during the spring migration.

### INTRODUCTION

The Platte River in Nebraska is a staging area for nearly 500,000 sandhill cranes each spring. The cranes rest and feed along the river for four to six weeks during their migration from wintering grounds in Mexico, New Mexico, and Texas enroute to their nesting grounds in Canada, Alaska, and Siberia. They spend their days in the fields adjacent to the Platte, dancing, loafing, and feeding on waste corn, earthworms, snails, and other invertebrates. Overnight the cranes roost on shallowly flooded sandbars of the Platte River. In addition to sandhill cranes, the remaining natural flock of whooping cranes, which now numbers 109 birds, migrates through Nebraska each spring and fall. Whooping cranes generally use the Platte as a stop-over habitat, spending one or two nights during migration. An estimated 7 to 9 million waterfowl and nearly 240 species of migratory birds use the Platte each year (Krapu 1981; Currier et al. 1985).

Major changes have occurred in the channel morphology and riparian vegetation of the Platte since water diversion for irrigation began in the mid 1800s (Eschner et al. 1981; O'Brien and Currier 1987). A reduction of peak discharge of more than 70% and storage of sediment in on-stream reservoirs are primarily responsible for these changes. Prior to 1860, the Platte was a braided stream, 2 km or more in width, characterized by a sandy, unvegetated streambed, and bordered by prairies, marshes, sloughs, and wetland meadows. Few trees grew along the river's course except in isolated draws and on scattered river islands. Today the

river is dominated by stretches of narrow multiple channels, threading around permanently vegetated woodland islands. The active river channel has narrowed, allowing cottonwood *Populus deltoides* and willow *Salix exigua* to grow over much of the former floodplain (O'Brien and Currier 1987). Only a few segments of the original braided stream remain.

Habitat for cranes, waterfowl, and other migratory birds has suffered under these changes (Currier et al. 1985). Losses in channel width have caused some roost sites to be increasingly vulnerable to disturbance and predators; other sites have been completely eliminated. In some river segments, 97% of the roost habitat has been lost. To maintain the existing habitat for migratory birds, instream flows that provide adequate roost sites and maintain wide-open channels need to be designated on the Platte. In addition, enhancement and restoration of roost habitat will help to disperse the cranes and lessen the chance of a catastrophic event that could eliminate a major portion of the population. In this paper, reclamation and restoration programs undertaken by the Platte River Whooping Crane Trust are reviewed and evaluated, and recommendations are made for future management.

### HABITAT PLAN

#### Platte River Trust

The Platte River Whooping Crane Habitat Maintenance Trust was formed in late 1978 in a court-approved settlement of a dispute over the construction of Grayrocks Dam

and Reservoir in Wyoming. The State of Nebraska and the National Wildlife Federation had sued the developers of the project, contending that the depletion of water upstream would affect the habitat for whooping cranes and other migratory birds in Nebraska. The Trust is charged with the responsibility for managing, maintaining, and restoring migratory bird habitat on the Platte. A \$7.5 million endowment supports the Trust's programs to acquire land and water rights, to conduct scientific research, and to manage habitat for the benefit of migratory birds. Research and management programs are currently directed toward endangered and threatened species (bald eagle *Haliaeetus leucocephalus*, whooping crane, least tern *Sterna antillarum*, and piping plover *Charadrius melodus*) and those species that occur in great numbers on the Platte (sandhill crane, ducks, and geese).

### Habitat Complex

The Trust's principal management area is a 130 km stretch of the Platte between Overton and Grand Island, Nebraska. Major bridge crossings dissect this stretch of the river into 11 segments. Each segment seems to represent a distinct biological unit as cranes tend to avoid the disturbed habitat near the bridges. Extensive human disturbance in one segment near Kearney makes this an unlikely site for management. For the 10 remaining river segments, we have identified minimum specifications for suitable crane roost site complexes.

A minimum water-filled channel roost area 150 m in width and 3.5 km long should be maintained free of woody vegetation. The roost channel should be bordered by a 0.8 km wide buffer zone composed of open river channel or grassland. The buffer zone may also contain forest, especially where this vegetation type serves as a "screen" around disturbances. Forested areas, however, should be limited to one side of the river channel in order to maintain the open character of the roost. Within the buffer zone no human disturbances (e.g., buildings, roads) should be visible from the roost. Immediately adjacent to the roost channel should be 260 ha of grassland and a minimum of 40 ha of standing water wetlands. This grassland/wetland complex should be surrounded by a 0.8 km-wide disturbance-free buffer zone of cropland or grassland.

An additional 700 ha of grasslands, including 120 ha of wetlands should be located within 5 km of the roost channel. Grassland parcels should be a minimum of 32 ha in size. Cropland should also be included in the habitat complex, but no minimum area is specified because this component is not currently limiting in any segment.

The area and juxtaposition of the habitat components outlined above are based on existing roost site complexes at Mormon Island, Shoemaker Island, and Fort Farm Island, where sandhill cranes roost in large concentrations. If a roost site complex were to be established in each bridge segment, a suitable site would be available within 6.5 km of any point on the river. The distance between complexes would be no greater than 13 km.

### Roost Site Characteristics

In addition to an open channel, specific roost site characteristics for sandhill cranes and whooping cranes have been described for riverine sites (Krapu 1981; Johnson and Temple 1980; Lingle et al. 1984; Lingle et al. 1986). For whooping cranes these are: 1) a wide water-filled channel, 155 to 365 m in width; 2) an unobstructed view from bank to bank as well as 200 to 350 m upstream and downstream; 3) slow flow, 2 to 6 km per hour; 4) shallow water, 5 to 130 cm in depth; 5) unvegetated sandy sediment on the river bottom; 6) at least 0.4 km from disturbances, or at least 0.2 km from a disturbance with a visual barrier; and 7) located within 4.8 km of a feeding site. Sandhill cranes require a similar roost, although they will tolerate channels as narrow as 50 m. The instream flow necessary to provide adequate roost habitat for whooping cranes and sandhill cranes is currently under study by the U.S. Fish and Wildlife Service, the U.S. Bureau of Reclamation, the Nebraska Game and Parks Commission, and the Platte River Trust. Preliminary findings suggest that a flow between 48 m<sup>3</sup>/sec and 58 m<sup>3</sup>/sec (1700 to 2000 ft<sup>3</sup>/sec) is probably sufficient to provide roost habitat.

### Feeding Habitat

On migration whooping cranes feed on grain and aquatic organisms such as frogs, fish, crayfish, and insects. Wetlands adjacent to the Platte provide aquatic organisms, but the numbers and size of these wetlands have declined greatly since the mid 1800s because of drainage and conversion to cropland. Sandhill cranes feed in wetland meadows, grasslands, and grain fields. They derive most of their nutrition (96% of the diet) from waste corn (Krapu 1981). Snails, earthworms, beetles, and other invertebrates comprise the remaining 4% of the diet. Although invertebrates account for little of the diet, cranes spend 42% of their time in alfalfa, wetland meadows, and grasslands where they derive these foods. Sandhill cranes also show a preference for grasslands with standing water in the immediate vicinity of the river roost (Krapu 1981; Iverson et al. unpublished).

## HABITAT PRESERVATION

### Geographical Database

To help identify suitable locations for roost site complexes in each bridge segment, the Trust developed a geographical information system database (GIS) in 1982. Land cover types including cropland, woodland, grassland, river channel, and disturbance features (e.g., roads, homesteads, and powerlines) were mapped from aerial photography in an area extending 5.5 km to each side of the river channel. Using a sandhill crane/whooping crane roost model developed by Armbruster and Farmer (1980), the database was analyzed to identify unobstructed river segments greater than 50 m in width for sandhill cranes and greater

than 150 m in width for whooping cranes. Based on the openness of the channel, isolation from disturbance, and proximity to feeding areas, the major roost complex in each river segment has been identified. Recent whooping crane sightings on the Platte lend support to the model since they have occurred primarily in areas predicted as the most suitable sites within a particular bridge segment.

#### Habitat Acquisition/Easements

The Trust's initial management efforts have been directed toward preservation of the remaining high quality roost and feeding habitat along the Platte. It is far easier and much less expensive to maintain roost sites and the adjacent wetland meadows than to reclaim these land types from degraded habitat. In addition, younger stages of woodland encroachment (5 to 15 years old) are easier to clear than old forest growth (40 to 50 years). In several bridge segments a roost complex can be maintained by clearing 3 to 8 m tall trees and shrubs from the floodplain surrounding the existing roost habitat. In other segments, however, 15 to 18 m tall (50 to 60 foot) forest trees will need to be removed to re-establish the roost complex.

The Trust currently manages about 2800 ha (7000 acres) of habitat through fee title and easements. The National Audubon Society manages an additional 480 ha bird sanctuary near Kearney, Nebraska. It is estimated that 10,000 to 12,000 ha (25,000 to 30,000 acres) of habitat will be required to complete the 10 roost site complexes. Today only 25% of this habitat is under protective management. Acquisition efforts have been directed primarily toward purchase of river roost sites and adjacent wetland meadows. Easements have been used to maintain buffer zones around the habitat complex and to protect grasslands from being converted to cropland. The Trust has been aided in its acquisition efforts by The Nature Conservancy through their fundraising and wetlands programs.

## RECLAMATION AND MANAGEMENT

#### Maintenance of Riverine Roost

In 1982, the Trust began clearing tree and shrub communities from the river channel adjacent to two high-use roost sites near Mormon and Shoemaker Islands. Clearing was done in mid summer and early fall when discharge in

the Platte was low and it was possible to drive equipment across river channels. Chainsaws and a 65 hp, 4-wheel drive tractor fitted with a heavy duty Bushhog mower were used in this initial clearing. A variety of mechanical and chemical techniques including shredding, shredding followed by disking or herbicide applications, and herbicide applications on standing vegetation, were experimentally investigated (Currier 1984). Vegetation at these sites ranged from 2-8 m in height and was composed of dense stands of 5-15 year growth cottonwood, willow, and false indigo *Amorpha fruticosa*. Trees were generally 8-10 cm in diameter, but occasionally 30-40 cm diameter trees were encountered. Because woodlands were relatively young at these sites, over 80 ha were cleared in a seven-week period (less than 400 man-hours).

Under this experimental phase, we were reluctant to purchase heavy equipment until a working methodology for clearing had been determined. Disking was therefore conducted under a contract with an equipment operator. A 90 cm notched-blade, 2-way disk and a D7 track-driven Caterpillar tractor were used. The disk was provided free of charge by Miller Manufacturing of Grand Island, Nebraska. The Caterpillar work ranged from \$80 to \$100 per hour, including a \$5 per hour maintenance cost to replace the rollers on the tractor following a season of work. The sand on the riverbed is very abrasive to the under-carriage of track-driven vehicles, making maintenance costs very high.

The costs for the experimental treatments are listed in Table 1, and range from \$194 to \$459 per ha (\$77 to \$183 per acre). Shredding followed by disking was the most effective and environmentally acceptable treatment studied. Shredding alone was not effective in the control of woody plants. As little as eight weeks following shredding, tree and shrub regrowth was 0.5-1.0 meters in height. Subsequent shredding eliminated some regrowth, but 75-80% of the stumps remained alive. Shredding followed by either an application of Graslan (tebuthiuron) at a rate of 2.26 kg/ha or a 1 1/2 percent solution of Roundup (glyphosate) was also effective in controlling nearly 95% of the regrowth. Although herbicides are effective, we are not recommending widespread use because of uncertainties about their long-term environmental effects.

Roundup applied to standing shrubs resulted in 85% to 95% control. There were problems in uniformly applying the herbicide in this treatment, most likely accounting for the slightly lower rate of control. It is recommended that

#### Dollars per hectare<sup>a</sup>

Treatment	Area ha (acre)	Labor	Administration	Maintenance	Fuel and Chemical	Equipment <sup>b</sup>	Total cost per ha (acre)
Shred	56 (140)	38	10	40	8	110	\$206 (82)
Spray	7 (17)	25	8	20	48	93	\$194 (77)
Shred + Disk	10 (25)	200	25	88	20	110	\$443 (177)
Shred + Spray	9 (23)	63	18	60	115	203	\$459 (183)
Total Area	82 (203)						

**Table 1.** Costs associated with various treatments in the experimental clearing operations at Mormon and Shoemaker Islands in 1982.

<sup>a</sup>Acres conversions have been provided to aid land managers in the U.S. who use English Units.

<sup>b</sup>Costs based on a \$37,000 investment with an estimated 4-year life.

a colored dye be used in the spray solution if this treatment is to be used. Graslan was applied by hand-held applicators in a pelleted form, and was more uniformly distributed than the Roundup. Graslan controlled over 95% of the standing shrubs. No specific cost calculation was made for the standing shrub treatment, however, since the costs are essentially the same as those for shredding followed by herbicide treatment. Although standing trees and shrubs are killed by the herbicides, they must still be removed in order to provide unobstructed views from the roost site. If shredding must be done anyway, a more effective method is to shred first and then apply herbicides to regrowth.

In 1983 we purchased a large 125 hp "Klearway" to help with river clearing operations. The Klearway has two 180 kg flywheels each with two 2.5 cm thick blades, on a front-mounted articulated cutter head. The machine is driven through the vegetation, chipping trees and shrubs up to 120 cm in diameter. The Klearway cost about \$110,000 and was originally designed for the maintenance of woodlands beneath transmission lines. With the Klearway we were able to clear less accessible sites and larger trees than with the tractor and Bushhog.

In combination with high flows in the Platte, shredding followed by disking not only controlled the vegetation on river islands, but also completely eliminated some islands elevated as much as 1 m above the streambed. With this methodology about 25 km of river channel have been cleared and maintained during the past five years. New seedlings continue to develop on the streambed, but subsequent disking every two to three years, at an estimated cost of less than \$250 per ha (\$100 per acre), should maintain roost sites indefinitely.

Because clearing increases unobstructed channel width, new roost areas may be provided adjacent to cleared islands. The islands themselves provide little additional roost habitat because they are generally elevated above the riverbed (1 m). If these islands are scoured from the bed or are flooded during high river stages, they can provide additional roost sites. During flooding, they may provide the only roost sites because adjacent areas may be too deeply covered by water for roosting.

#### Reclamation of Riverine Wetlands

In 1984 the Trust began a program to convert a portion of forested floodplain into a wetland meadow complex consisting of an open-channel roost site and adjacent grasslands with surface water sloughs. The site chosen for this work was located near Elm Creek, just downstream of the Kearney Diversion Canal. The river channel near the diversion (north side) has remained a fairly open, treeless channel with an unobstructed width of 0.4 km. Maintenance and enhancement of this roost site are currently underway using the clearing and disking techniques described earlier in this paper.

To the south of this channel is an area of former riverbed, approximately 160 ha in size, which is now dominated by 40 to 60 year old cottonwoods, with an understory of rough-leaf dogwood *Cornus drummondii*, willow *Salix*

*rigida*, red cedar *Juniperus virginiana*, hackberry *Celtis occidentalis*, green ash *Fraxinus pennsylvanica*, and Russian olive *Elaeagnus angustifolia*. Several sloughs parallel the main river channel at this site. These sloughs are supplied primarily by water seeping under the diversion dike. At high river discharges between 340 to 570 m<sup>3</sup>/sec (12,000 to 20,000 ft<sup>3</sup>/sec), surface water flows across the site. Before 1938, this area was characterized by an open, treeless river channel, bounded by wetland meadows to the north and south. As water levels declined in the Platte, water levels in the adjacent wet meadows also declined. There is little potential for reclamation of these former wet meadows at Elm Creek, because they are no longer in close proximity to the roost channel (over 1.2 km from the roost) and they have a limited water supply. The lower elevation floodplain forest is more suitable for rehabilitation.

At Elm Creek, the shrub understory was initially cleared with the Klearway. Then trees were felled with chainsaws. The larger trees (about 25% of the forest) were cut and sold for lumber for pallets and packing material. Most of the trees were too small to be used for lumber and were piled and burned. Some trees were left uncut along the river channel, adjacent to some sloughs, and on a few ridges to provide "islands" of habitat for roosting raptors, herons, and other migrants. Less than 10 ha (6%) of the forest was left uncut. Shrub communities will be maintained on a few sites through periodic mowing or shredding.

Forest clearing is an expensive operation. It involved the purchase of a number of pieces of heavy equipment in addition to the Klearway, including a 125 hp Steiger tractor, a skid-loader, a 2-yard frontend loader, a semi-tractor with a trailer and dump box, a heavy-duty notched-blade farm disk, a pickup truck, and several heavy-duty saws. We employed a three-man work crew for fieldwork and equipment maintenance. It has taken more than three years to clear the 160 ha at this site. Costs associated with the clearing totalled \$1815 per ha (\$726 per acre). The most substantial costs were for labor (\$660/ha) and equipment expenditures (\$465/ha). Equipment costs were distributed over a ten year estimated life. Costs for administration (\$325/ha), maintenance (\$235/ha), and fuel (\$103/ha) were moderate.

Proceeds from the sale of lumber (\$14,900) offset some of the operational costs. After consideration of this income, final costs were \$1720 per ha (\$688 per acre). The lumber operation was an attempt to use efficiently the natural resources at the site. In practical terms, however, the lumbering slowed the clearing work and provided so little income that it was not worth the time and effort. Costs of clearing could be reduced substantially if trees were simply felled, piled, and burned.

Clearing is only the first step in maintaining treeless grasslands adjacent to the river channel. Much of the cleared area at Elm Creek now has 1 to 2 m high shrub and tree regrowth. A combination of shredding, burning, herbicide applications, and grazing techniques will be used to control this regrowth. Experimentation with burning has met with limited success, primarily because there is so little cover to carry a fire. Most burns have been too cool to



arrest woody growth. The site has been fenced and plans for grazing are currently underway.

Double cutting, or repeated shredding of regrowth, will also be investigated as a technique to deplete below-ground energy reserves of plants and eventually kill woody regrowth. This treatment is most effective in mid-summer when plants are actively growing. Herbicides will be employed only as a last resort in controlling regrowth, because of our concern for long-term persistence of toxins.

Water control structures will be placed at the downstream end of the Elm Creek tract in order to establish semi-permanent wetlands during crane migration. These structures will consist of low-level dikes, less than 2 m in height, probably with an adjustable irrigation riser to control water levels, and an emergency spillway to accommodate occasional floods. A ground survey has been conducted to determine the most effective location for these water control structures. We will probably employ a step-wise plan, constructing a single dike and examining the extent of the created wetland before proceeding with additional work. Applications are currently being filed with the U.S. Army Corps of Engineers to allow the use of fill material in a wetland. We hope approval of the permits will allow construction to begin in the fall of 1988. No cost estimate is available yet for this work.

Once water control structures are in place and regrowth is under control, long-term monitoring programs are planned. These programs will involve studies to investigate

the response of plant communities, aquatic invertebrates, and migratory bird populations to fluctuations in water levels in re-created wetlands. Results of these studies will provide a baseline for future wetland restorations elsewhere on the Platte.

#### CONCLUSION

Although forest clearing is expensive, it is the only alternative in some river segments if roost sites and adjacent wetlands are to be maintained. It is within the Trust's economic means to clear small tracts of woodland along the Platte, but it will not be an easy task, nor will we complete it quickly. We remain confident, however, that adequate roost site complexes can be maintained with the clearing and diking techniques described in this paper. It is uncertain, however, if instream flows vital to the continuing existence of migratory birds on the Platte will be maintained. Several additional projects to divert water from the Platte are currently being considered by governmental agencies. We hope that no further water allocations will be granted until instream flows for wildlife are designated. We are pleased that the delegates to the 1987 International Crane Workshop unanimously approved a resolution to that effect. It is the Trust's goal that through responsible water and habitat management, the Platte River will continue to provide a place for cranes, waterfowl, and other migratory birds long into the future.

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## AUTUMN MIGRATION OF GREATER SANDHILL CRANES FROM UPPER MICHIGAN, U.S.A.

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### ABSTRACT

During September 1985 to February 1986, 17 greater sandhill cranes *Grus canadensis tabida* from Seney National Wildlife Refuge (Seney NWR), Michigan, were radio tracked to identify staging areas, migration stops, and wintering sites. They departed Seney from 19 September to 11 October. The last pair to leave was followed 11-15 October through central Wisconsin to Jasper-Pulaski State Fish and Wildlife Area (J-P), Indiana, the major stopover site for sandhill cranes in the Great Lakes population. Distance traveled per day (60-380 km) and flight speed (29-54 km/h) varied. During this time five other radioed birds were found in central Wisconsin. Birds remained in Wisconsin 3-45 days. All 17 radioed birds were found at J-P, where 95% (137/145) of birds uniquely color marked on Seney (1984-85) have been observed. Birds normally roosted on J-P, and most birds usually fed in corn, soybean, and winter wheat fields 0.3-7.0 km from J-P. Radioed birds remained at J-P 1-70 days and departed 26 October to 13 December. Three pairs were radio tracked from J-P on 24 November. Birds remained near their first overnight stops, approximately 140 and 200 km south of J-P, 9-12 days because of poor weather conditions. Attempts to track them further were abandoned because of poor weather. In a second tracking effort, birds followed 12-16 December from J-P to central Florida made two overnight stops in Indiana, and one each in Tennessee and Georgia. Approximate distance traveled each day varied from 46 to 400 km. Fourteen of the 17 radioed birds were located from Okefenokee NWR, Georgia, to north of Lake Okeechobee, Florida, in five aerial surveys, 16 December 1985 to 24 February 1986. No radioed birds were found on wintering areas on 10 March 1986. All radioed birds were located on or near Seney in 1986.

Migration routes of greater sandhill cranes in the Great Lakes population in Wisconsin and Minnesota have been determined (Melvin 1977a; Toepfer and Crete 1979; Anderson et al. 1980) and some wintering areas have been defined (Williams and Phillips 1972; Nesbitt 1977; Melvin 1977b; Nesbitt and Williams 1979; Toepfer and Crete 1979; Walkinshaw 1982). But the migration route, major stopover areas, and specific wintering areas were not known for sandhill cranes that breed in Michigan's Upper Peninsula (UP).

This migration study, funded by the U.S. Fish and Wildlife Service, Office of Endangered Species, and supplemented in 1986 by funds from the Michigan Department of Natural Resources (DNR), was part of a larger effort to evaluate the suitability of sandhill cranes nesting in the eastern portion of the UP for a cross-fostering program with whooping cranes *Grus americana*. Long-range plans for successful recovery of the whooping crane include establishment of at least two additional populations of at least 20 nesting pairs each, disjunct from the Wood Buffalo population (Whooping Crane Recovery Team 1980). One goal of the Whooping Crane Recovery Plan was to conduct pre-release banding and migration studies with sandhill cranes.

The specific objectives of this segment of our research were to determine the (1) migration route from Seney to

J-P, (2) arrival and departure dates and distribution at J-P, (3) migration route taken from J-P to wintering areas in southern Georgia and Florida, and (4) winter distribution.

### STUDY AREAS

#### Seney National Wildlife Refuge

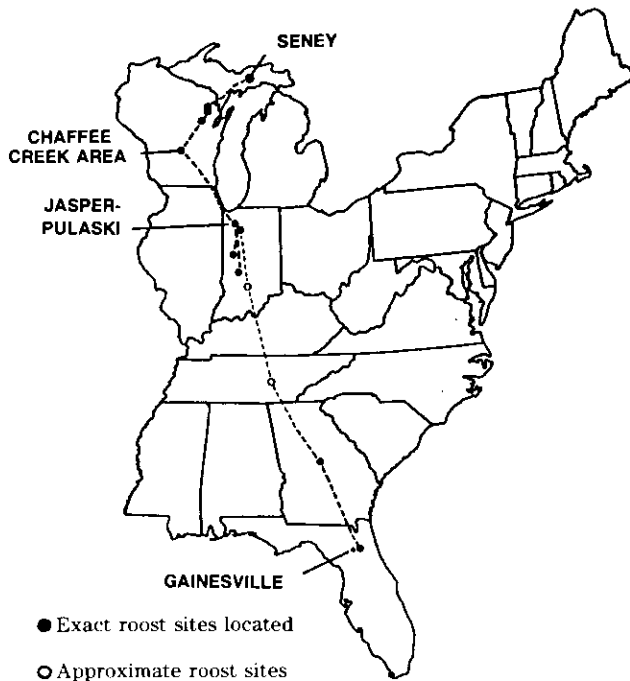
Seney is a 38,630-ha refuge in Schoolcraft County in the east-central portion of the UP (Figure 1). The refuge is part of the Great Manistique Swamp and is a vast and level sand plain 222 m above sea level, grading S 15°E at 3-6 m/km (Anderson 1982). Refuge vegetation is estimated to be 54% marsh, grassland, and shrub; 21% upland conifer; 9% upland hardwood; 7% lowland conifer; 7% open water; and 2% lowland hardwood (U.S. Department of the Interior 1978).

#### Jasper-Pulaski

J-P, a state Fish and Wildlife Area, is in the sandy lacustrine plain of northwest Indiana, 60 km south of Lake Michigan (Figure 1); it is the major spring and autumn stopover area for eastern greater sandhill cranes (Lewis 1977; Loovorn and Kirkpatrick 1981). Cranes nested in the

vicinity of J-P prior to 1930, but then disappeared because of human encroachment and loss of habitat (Goold 1977). The area, however, was still used as a migration stopover. Autumn populations have increased from 135 individuals in 1942 to 2,500 in 1967, 8,700 in 1974 (Shroufe 1976), and 13,000 in the 1980s (Loovorn and Kirkpatrick 1981).

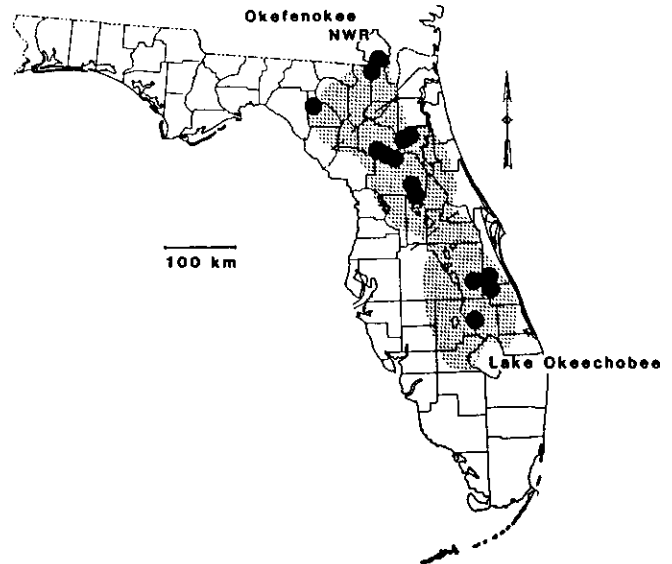
The refuge, initially established in 1929, now contains 3,217 ha, 810 of which are wetlands (Goold 1977). Its three vegetational communities are shallow aquatics, lowland hardwoods, and upland hardwoods. In 1967, construction of 14 permanent, shallow impoundments provided more than 238 ha of permanent water that became the cranes' wetland roosts (Shroufe 1976). A 243-ha upland field on the refuge and near this wetland roost complex has been planted in winter wheat, corn, buckwheat, and clover as food for waterfowl (Shroufe 1976; Loovorn and Kirkpatrick 1982). Most land surrounding J-P has been cleared or drained for corn, soybean, and winter wheat production.



**Figure 1.** Migration route and stopover sites of greater sandhill cranes banded on their breeding grounds on Seney National Wildlife Refuge, Michigan, 11 October 1985 to 24 February 1986.

#### Florida

Cranes within the winter search area (Figure 2) were located in northern Florida and southern Georgia primarily in swamps and prairies, and in the central region in prairies, pastures, and muck farms. Birds in the southern portion primarily used pastures and associated ponds.



**Figure 2.** Winter locations of 14 greater sandhill cranes banded on their breeding grounds on Seney National Wildlife Refuge, Michigan, 16 December 1985 to 24 February 1986. Cross-hatching indicates area searched; dashed lines separate northern, central, and southern wintering areas.

#### METHODS AND MATERIALS

##### Capture and Banding

Cranes were captured and individually color marked on Seney, 1984-86, and on the East Unit of the Hiawatha National Forest (EUHNF), about 90 km east of Seney, in August 1986. Most birds were captured by rocket-netting (Urbanek et al. this proceedings), but some flightless or recently fledged chicks were captured by hand. Radio transmitters were placed on one member of selected pairs, preferably with chicks, to facilitate subsequent nest locations of successful parents. At Seney, non-radioed cranes were fitted with three to six red, white and green vinyl leg bands, 19 mm high, stacked above the tibiotarsal joints. Each leg held a minimum of one or a maximum of three bands. The color of the lower left band indicated trapping year. A USFWS hand was placed below the right tibiotarsal joint. Solar-powered radio transmitters were attached above the tibiotarsal joint in a fashion that incorporated them into the color-marking scheme. Modifications from the procedure used by Melvin et al. (1983) included attaching the leg band holding the transmitter in two pieces instead of a single unit, and gluing with plastic pipe cement those two pieces and the transmitter into a single unit. No bolts were used. Holding time was approximately one-half hour. The EUHNF marking scheme was similar except blue bands replaced red ones.

All radios were constructed by Telemetry Systems, Inc., Mequon, Wisconsin. Each was a three-volt transmitter powered by two Ni-Cad cells and 10 solar cells. They functioned in the 164-165 MHz range. Reception ranges in km were 1) ground to ground 0.8-4.8, 2) air to ground 4.8-10.

and 3) air to air 48-240. Melvin and Temple (1983) reported respective ground-to-ground and air-to-ground ranges of 0.8-16 and 23-32 km. The two major transmitter problems were transmission failure after periods of sunless days and antenna breakage approximately one year after attachment.

### Radio Tracking

In 1985, departure dates from Seney were determined by a ground crew using portable telemetry receivers. The Ohio DNR twin engine Partenavia airplane was used for aerial tracking along the migration route. Two H-antennae were bolted to chrome-moly 4130 steel poles projecting from the wings' inspection plates. One antenna was vertically oriented, tilted 15° downward, and angled approximately 60° from a forward facing position. This antenna was used for the search mode in which a 360° turn was made every 10-15 min along the search line until the sought-after signal was received. The other antenna, forward facing and horizontally oriented, was used for directional accuracy and for homing on a detected signal. A switch box controlled reception from either or both antennae.

Because of financial constraints, migrating birds were not monitored continuously from the air except immediately before and after morning departure and approximately one hour before roosting. Once an initial bearing on the flight path was determined each morning, the plane flew ahead to a convenient airport and birds were tracked from the ground as they flew overhead and out of receiving range. The flight path was then rechecked from the air, and the leapfrog pattern was repeated.

Arrivals of radioed birds at J-P were monitored daily from the Goose Pasture and surrounding areas 3 October to 20 November. Radioed cranes were located at feeding, loafing, and roosting sites 1-23 November and 7-13 December. Band combinations of non-radioed birds were determined whenever possible.

Presence and location of radioed birds in Georgia and Florida were determined in six aerial surveys 16 December 1985 to 10 March 1986. Four surveys were conducted in a Florida Game and Fresh Water Fish Commission (FGFWFC) Cessna 172, and two were flown in private planes. Antennae were attached to wing struts with duct tape.

In 1986, a migration monitoring station, consisting of a Telonics scanner receiving input from a tower-mounted, seven-element Yagi antenna, was established on the west shore of Gulliver Lake 16 km south of Seney to detect departures of radioed cranes and to supplement ground tracking efforts. The antenna was mounted 10.8 m above the ground surface and directed WNW. The scanner was attended continuously from 0900 to 1500 hours or longer each day from 11 September to 17 October. Presence of cranes in Wisconsin was determined by aerial survey in and around the Chaffee Creek area, about 100 km north of Madison, on 30 October. Arrivals of radioed cranes at J-P

were monitored daily from the Goose Pasture and surrounding areas 16 September to 11 November. Intensive searches for individually color-marked birds were made 25 October to 21 November.

## RESULTS

### Capture and Banding

Two hundred and ten cranes were captured and individually color marked in the UP, 1984-86. Thirty-three were fitted with radio transmitters. Post-banding mortality, primarily of unfledged chicks, reduced the number of surviving individuals to 196 (Table 1). Thirty-one unfledged chicks (3 in 1984 and 14 each in 1985 and 1986) were initially captured by hand.

Year	Seney		EUHNF		Number Alive Autumn 1986
	Number Color Marked	Number Radioed <sup>a</sup>	Number Color Marked	Number Radioed <sup>a</sup>	
1984	72				70
1985	79	17 <sup>b</sup>			74
1986	50	13	9	3	52
Total	201	30	9	3	196

**Table 1.** Summary of greater sandhill cranes individually color marked and radio tagged in the Upper Peninsula of Michigan, 1984-86.

<sup>a</sup>Included in total number color marked.

<sup>b</sup>Two died summer 1986.

### Migration from Seney to J-P

In 1985, radioed birds (N = 17) departed Seney from mid-September to 11 October and remained in Wisconsin 3-45 days (Table 2). The last radioed crane to depart Seney in 1985 was tracked with its mate through central Wisconsin to J-P, 11-15 October (Figure 1). Total distance travelled was 775 km — 196 km more than the straight line distance between the two points. Distance traveled/day and flight speed varied from 60 to 380 km and 29 to 54 km/h, respectively. The faster speeds and longest distances were achieved when skies were sunny and clear and winds were from the northwest.

Year	Depart Seney	In Wisconsin	Arrive J-P	Depart J-P
1985	First 19 Sept. Last 11 Oct.	35% (6/17) present on 13 Oct.	<3 Oct. 20 Nov.	26 Oct. 13 Dec.
1986	First 16 Sept. Last 15 Oct.	22% (7/32) present on 30 Oct.	27 Sept. -	1 Nov. -

**Table 2.** Autumn migration departure and arrival dates of greater sandhill cranes radio tagged in the Upper Peninsula of Michigan, 1985 and 1986.

Although the last pair to depart in 1985 roosted alone the first night out of Seney, they joined a flock of more than 100 cranes north of Navarino Wildlife Area, Wisconsin, on 12 October and migrated the next day with 32 cranes to the Chaffee Creek area in Marquette County, Wisconsin, where the pair again associated with larger feeding and roosting flocks. They departed on 15 October, however, as an isolated pair, even though they had been feeding in a cornfield with 192 other cranes. An additional five radioed birds were detected in Marquette and Waushara counties of Wisconsin on 13 and 14 October (Figures 1 and 3).

In 1986, monitored radioed birds on Seney (N=11) departed 16 September to 16 October. Seven birds were located in Marquette and Waushara counties, Wisconsin, on 30 October (Table 2), and locations were similar to those in 1985 (Figure 3).

#### J-P

In 1985 and 1986 radioed birds (N=17 and N=31) arrived at J-P from before 3 October to 20 November and from 27 September to 11 November, respectively (Table 2). In 1985 they stayed at J-P from 1 to 70 days ( $x=35.8 \pm 6.3$  ISE), and the mean number present from 3 October to 24 November was 12 (Figure 4). All radioed birds were detected in 1985 and in 1986. In 1984, 1985, and 1986, the respective percentages of individually marked birds thought to be alive (radioed and non-radioed) that were observed at J-P were 96 (67/70), 95 (137/145), and 87 (171/196). Six of the nine birds marked on the EUHNF were seen at J-P in autumn 1986. Over the three years of observation, all but 3 (95.7%), 5 (93.3%), and 18 (66.0%) cranes from the respective 1984, 1985, and 1986 banding years have been observed at least once at J-P. The percentages observed from each banding year increased with the number of years of observation. For example, over the three-year (1984-86) observation period for birds banded in 1984, the percentages observed increased from 74 to 93 to 96. The return from birds banded in 1986 probably will also increase from 66% with subsequent observations.

Radioed cranes fed in soybean and corn stubble and winter wheat fields up to 7.0 and 9.9 km from J-P boundaries in 1985 and 1986, respectively (Figure 5). Although most cranes roosted on the refuge wetlands, several off-refuge roosting areas were detected in 1985 and 1986. An increase in off-refuge roosting areas was detected in 1985 when heavy rains flooded farm fields adjacent to the refuge (Figure 4).

#### Migration from J-P to Winter Areas

Two pairs of cranes were tracked from J-P on 24 November 1985 to their first overnight stops in flooded, harvested cornfields, 24 km north-northeast of Greencastle and 1.5 km southwest of Gosport, Indiana, 140 and 200 km south of J-P respectively (Figure 1). Unfortunately, the birds remained at these sites 9-12 days because of poor migrating conditions. When they did depart again, the transmitter signals were too weak from numerous con-

secutive cloudy days to permit tracking. We returned to J-P on 7 December and began again. Nine additional radioed birds had departed J-P in the interval, but four were still present (Figure 4); they were monitored until they left on 12 and 13 December.

Birds were followed from J-P to central Florida 12-16 December 1985. They made two overnight stops in Indiana and one stop each in Tennessee and Georgia (Figure 1). The approximate distance travelled each day varied from 46 to 400 km, and altitude varied from 30 to 1,200 m above

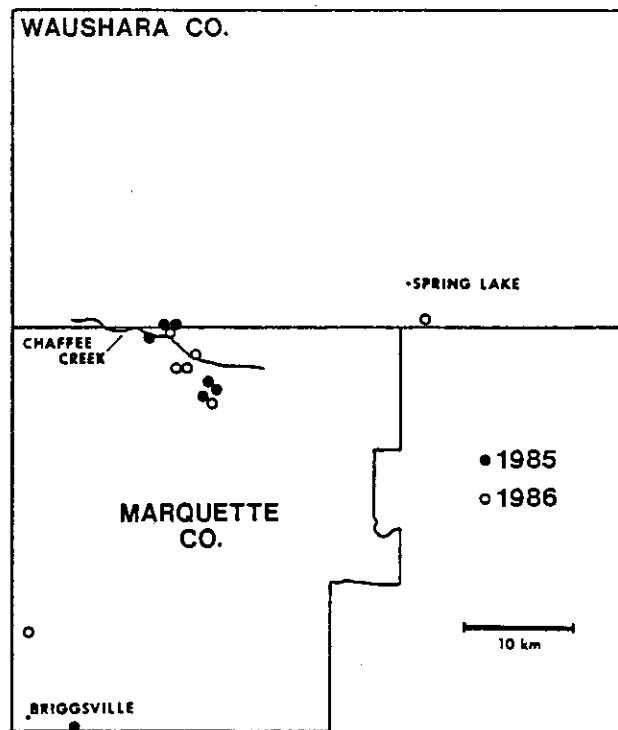


Figure 3. Fall stopover locations of greater sandhill cranes, banded on their breeding grounds on Seney National Wildlife Refuge, Michigan, in Marquette and Waushara counties, Wisconsin, 13-14 October 1985 and 30 October 1986.

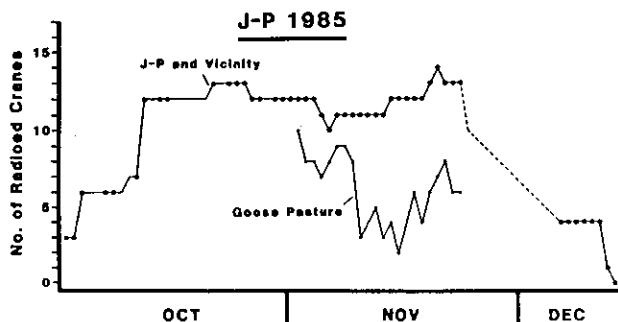
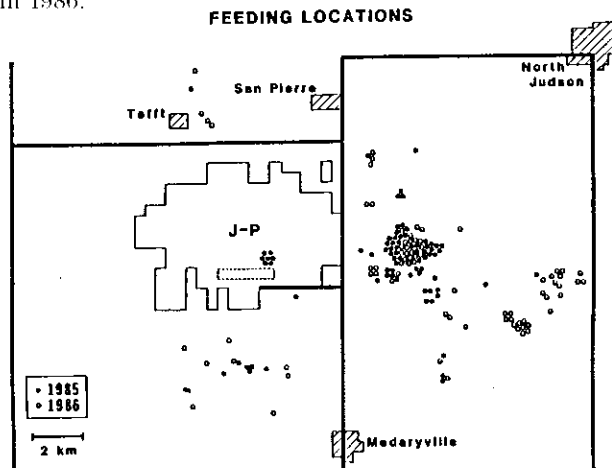


Figure 4. Presence of 17 radio tagged greater sandhill cranes on or near Jasper-Pulaski State Fish and Wildlife Area, Indiana, 3 October to 13 December 1985. The sharp decrease in crane numbers at Goose Pasture occurred at a time of heavy rain which correlated with increased off-refuge roosting.

ground, depending on weather conditions. Fourteen of the 17 radioed birds were located from Okfenokee NWR, Georgia, to north of Lake Okeechobee, Florida, in the first five surveys, 16 December 1985 to 24 February 1986 (Figure 2). No radioed birds were found on wintering areas on 10 March. All 17 radioed birds were found on or near Seney in 1986.



**Figure 5.** Feeding locations of radio tagged greater sandhill cranes on or near Jasper-Pulaski State Fish and Wildlife Area, Indiana, autumn 1985 and 1986. Each circle represents one crane observed on one day.

## DISCUSSION

The autumn staging and stopover areas and migration route of greater sandhill cranes nesting in the UP were unknown prior to our banding efforts in 1984. Lewis (1977) and Walkinshaw (1978 and pers. comm.) hypothesized cranes nesting in the UP passed through Michigan's Lower Peninsula and by-passed J-P. W. Taylor (pers. comm.) and Melvin and Temple (1981) suggested a Wisconsin route. Eleven of the 33 (33%) radioed birds were detected in Marquette and Waushara counties, Wisconsin, and of the 210 birds banded on Seney and EUHNF, 87.8%, and 66.7%, respectively, have been sighted at J-P. All radioed birds were detected at J-P in 1985 (N=17) and 1986 (N=31). No birds were banded in the UP have been sighted

in Jackson County, Michigan (R. Hoffman, pers. comm.). Our data, therefore, strongly suggests that cranes that breed in the UP migrate through Wisconsin and stop at J-P.

An important question remains: Why do UP cranes go so far out of their way into central Wisconsin en route to J-P? Cranes are traditional migrants and learn the migration route from their parents as clearly demonstrated by cross-fostering experiments in Idaho (Drewien and Bizeau 1977). Stopover areas used by UP cranes in central Wisconsin, i.e., Marquette and Waushara counties, are known staging/stopover sites for Wisconsin and Minnesota cranes (Melvin 1977a; Bennett 1978; Toepfer and Crete 1979). UP cranes likely are an expansion of a core Wisconsin population decimated by hunting and loss of wetlands in the late 1800s and early 1900s, and they have continued to return to their traditional stopovers as they expanded their range.

The route taken from J-P to wintering areas and the distribution in Florida were similar to those encountered by birds from Wisconsin (Melvin 1977b; Toepfer and Crete 1979; Anderson et al. 1980). Between the major stopover and wintering areas, cranes are primarily opportunistic roosters, and distances travelled depend primarily on weather (Melvin and Temple 1981); therefore, it is not surprising that the Tennessee and Georgia general stopover areas (Patterson 1978) were similar to the ones we detected. The stopover areas in west-central Indiana, however, were previously unknown (G. C. Iverson, pers. comm.).

Shroufe (1976), Goold (1977), Melvin (1977a), and Loovorn and Kirkpatrick (1981, 1982) described the typical autumn roosting and feeding pattern: cranes roost in the J-P wetlands, depart for the Goose Pasture and/or surrounding agricultural fields after sunrise and return before sunset. Weekly counts are made at J-P from August to January as birds leave the morning roost (Shroufe 1976; Goold 1977; J. Bergens pers. comm.). No authors have commented on the autumn off-refuge roosts we noted, with the exception of Loovorn and Kirkpatrick (1981, 1982), who felt off-refuge roosts were insignificant. We believe the discovery of significant autumn off-refuge roosting in flooded fields is potentially important because it may cause the weekly counts to underestimate the number of cranes present in the area.

## ACKNOWLEDGMENTS

Numerous persons contributed to the success of this project, and we are grateful to all of them. We especially acknowledge the Seney staff for their support, Steve Nesbitt (FGFWFC) for assistance in Florida, observers Jim Bergens, Mary Bishop, Alan Bennett, and John Wood, and pilots John Clem (Ohio DNR), John Weaver (FGFWFC), and Jim Kesel (Seney). We also thank US Forest Service personnel for their trapping efforts on the EUHNF.

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## THE CAPTIVE RELEASE PROGRAM FOR THE MISSISSIPPI SANDHILL CRANE

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### ABSTRACT

A total of 45 captive-raised juvenile Mississippi sandhill cranes *Grus canadensis pulla* were released in small groups each year (1981-1986) on the Mississippi Sandhill Crane National Wildlife Refuge, located in the southeastern corner of Mississippi. The young were raised at the Patuxent Wildlife Research Center (PWRC) from a breeding flock that originated from eggs collected in Mississippi. The juveniles were released into a population of wild, non-migratory cranes numbering fewer than 40. Before release, the cranes spent from four to six weeks in an acclimation pen on the refuge. The cranes were radio-tagged, ringed with individually numbered bands, and tracked during their lifetime. In 1987, 17 survive: 1 (age 7 years), 4 (age 5), 1 (age 4), 5 (age 3), 3 (age 2), and 3 (age 1). Mortality of 26 released cranes: predation (10), unknown causes (7), accidents (4), disease-parasites (4), and shot (1). Two were returned to PWRC. One mated and produced eggs with a wild female in 1985; they deserted the nest after disturbance. In 1987, five released cranes nested and produced eggs: 1 (age 5), 1 (age 4), and 3 (age 3). Three were paired with wild cranes; two released cranes formed a pair. Management includes restoration and improvement of habitats (breeding, feeding, and roosting) and predator control. The recovery plan goal is a total population of 100 cranes consisting of at least 30 pairs and 40 non-breeding birds.

### INTRODUCTION

Because many species of cranes are threatened by extinction, cranes are being released to bolster existing populations or to reintroduce them into places where they are absent. One method is to catch wild birds in one area and release them into another region (Nesbitt and Williams 1973). Another is to release captive-raised fledged cranes, either hand-reared (Nesbitt 1978), or parent-reared (Drewien et al. 1981). Drewien and Bizeau (1981), with a technique they called "cross-fostering," replaced sandhill crane eggs with whooping crane *G. americana* eggs in wild nests and allowed the sandhills to raise the chicks.

This report summarizes the history of releases of captive-raised Mississippi sandhill cranes into a non-migratory wild population that is threatened with extinction. The objectives of the Recovery Plan (Valentine 1984) are to prevent the extinction of the Mississippi sandhill crane, and to have a minimum population of 100 cranes consisting of at least 30 pairs and 40 non-breeding birds.

Zwank and Derrickson (1982), Mitchell (1984), Dewhurst (1985), and Mitchell and Zwank (1987) have reported on the releases and use of habitats. Personnel from the

Mississippi Sandhill Crane National Wildlife Refuge have written on the survival, mortality, movements, and associations of the released cranes (refuge files).

### STUDY AREA

Captive-raised sandhill cranes have been released on the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR), located in Jackson County, in the southeastern corner of Mississippi (see Figure 1). Established in 1974, the refuge now contains 7,221 ha of savanna and forest in three separate units: Fontainebleau, 476 ha; Gautier, 3,507 ha; and Ocean Springs, 3,238 ha (see Figure 1). Valentine and Noble (1970) described the environment and natural history of the Mississippi crane population.

The 1987 crane population is between 40 and 60 individuals, including 17 released birds. Management for breeding, roosting, and feeding habitats includes: (1) hand-clearing pine trees in breeding habitats; (2) harvesting and bulldozing pine trees and brush to create grasslands and croplands; (3) prescribed burning of savannas and forests; (4) constructing low level dams and water controls to create and maintain marshy areas; and (5) providing crops and supplemental food (Valentine 1983).

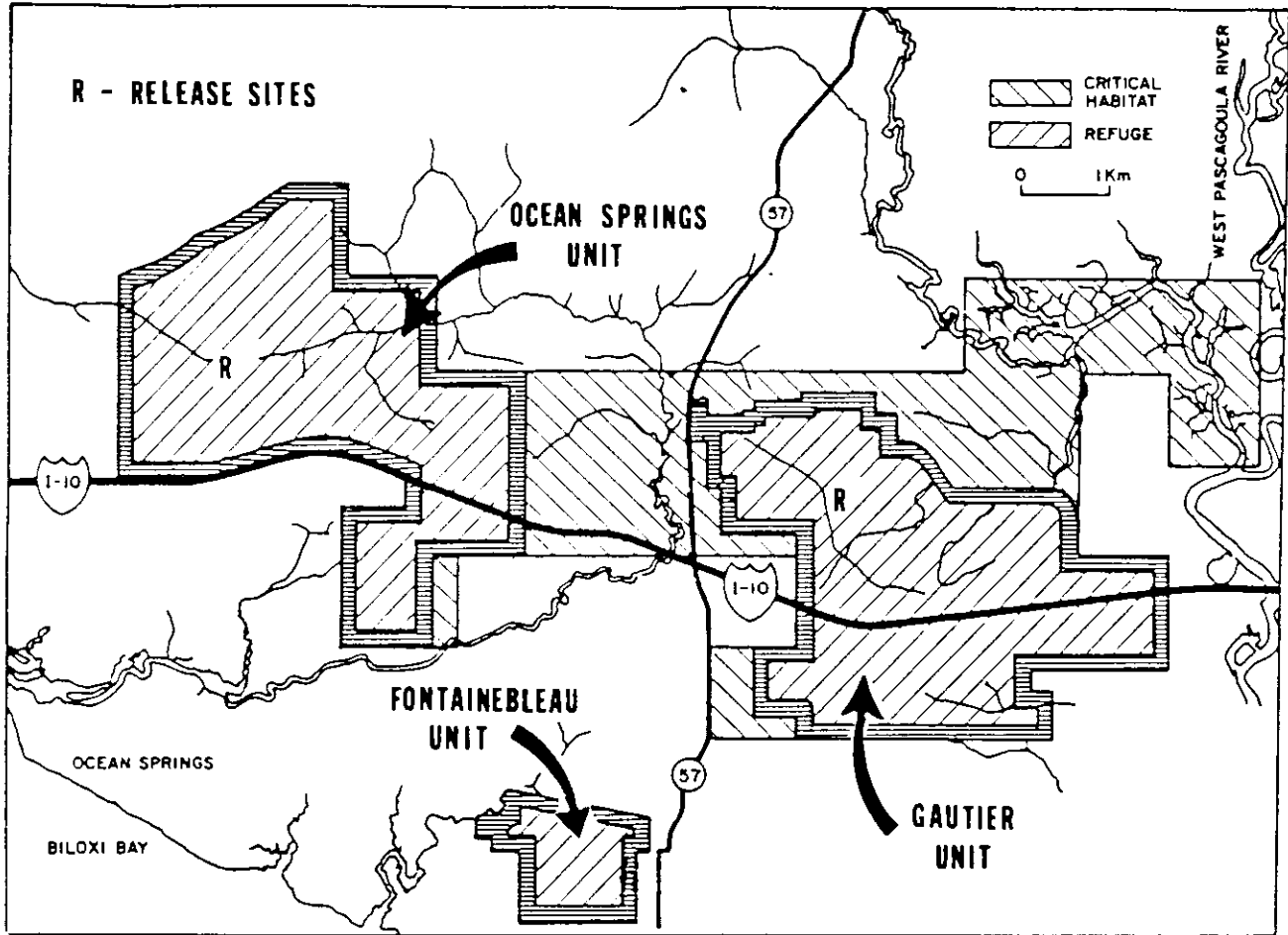


Figure 1. Mississippi Sandhill Crane National Wildlife Refuge and critical habitat, Jackson County, Mississippi.

## METHODS

Beginning in 1965, Valentine collected Mississippi sandhill crane eggs in Jackson County, Mississippi to originate a captive breeding flock. Eggs were collected (one egg from each two-egg clutch) in Mississippi (1965-1977, 1981-1982, 1985-1987). The first chicks were raised at John Lynch's aviary, in Lafayette, Louisiana, and later the project was moved to the Patuxent Wildlife Research Center in Laurel, Maryland. There are currently (as of 1987) 50 Mississippi cranes at PWRC, including nine breeding females, five pairs, and 15 young of the year.

The purpose of the release program is to increase the native population and to maintain genetic diversity. We have tried to collect eggs for captive propagation from all of the known territories (individual pairs).

Captive propagation has been described by several authors (Erickson 1975; Zwank and Derrickson 1982; Mitchell and Zwank 1987). Mississippi subadults destined for release are raised by their own, or foster parents, at PWRC. After they have fledged, the young are taken from their

parents and placed in a flight pen. The cranes are air-freighted in individual crates to New Orleans, Louisiana for pickup by the refuge staff.

### Radio Telemetry and Sight Tracking

Before they are put into the acclimation pen, a leg band mounted radio transmitter is fitted to each bird. Many of the radio transmitters have failed after a short time (less than a year). Since 1984, more efficient transmitters have been used. Released cranes have been trapped and the transmitters replaced (Logan and Chandler 1987). Combinations of colored and numbered leg bands are used to identify the individual cranes; numbered neck bands were used on five released in 1982.

Most of the 45 released cranes were followed with radio receivers by Loyd Mitchell, Donna Dewhurst, and Charlotte Wilson, graduate students under the direction of Philip Zwank, Louisiana Cooperative Wildlife Research Unit, Louisiana State University. Refuge personnel also recorded the movements and associations of the cranes. Intensive nest searches are made each spring and a crane census is made each fall and mid-winter.

## Acclimation Enclosures

A rectangular 2.4 ha pen is located at the edge of a large savanna in the Gautier Unit. Three-fourths of the pen is marshy and one-fourth slopes up to a well drained upland site. A small drain flowing from the hillside was ditched and diverted into the pen. If the stream goes dry, two stock watering tanks sunk into the ground provide emergency water.

The Ocean Springs acclimation enclosure, located 10 km northwest of the Gautier pen, was completed in 1984. The 1.5 ha release pen is built in a hexagonal shape with an attached catch pen. Part of the site is on level, well drained land, and part on marshy ground. Small ponds were bulldozed to hold drinking water. Observation towers were constructed at both pens.

Corn *Zea mays*, chufa *Cyperus esculentus*, winter ryegrass *Lolium* spp., and other crops are planted annually inside and outside the pens. Feeder sheds provide food pellets and shelled corn. Corn is scattered in fall and winter to attract and hold released and wild cranes. Twelve other crop fields, pastures, and grasslands are maintained at other sites.

The Gautier Unit contains the best crane habitats of the three refuge units so the greater number of releases have been made there. Fewer wild cranes frequent the Ocean Springs site. A wastewater treatment facility was constructed recently north of the Ocean Springs Unit and a wastewater spray grassland on the refuge now attracts both wild and released cranes.

## Releases

After a month to six weeks in the acclimation pen, the juveniles are caught, the brails removed, and the cranes allowed to fly at will. Some fly out immediately; others remain for several days. Most remain in the vicinity of the pens for some weeks and fly in and out of the pen where they feed and roost.

In January 1981, eight hatch-year (HY) 1980 and one HY 1979 captive-raised cranes were put in the Gautier pen. After about six weeks, the cranes were released in small groups at one week intervals. The nine cranes fed at the pen and stayed within 2.5 km for about eight months. Only one wild pair of cranes fed at the acclimation site during that winter. The released cranes were seen flying with wild cranes, but no permanent associations were formed. In the summer of 1981, the flock split into smaller groups, but six remained together into the fall. In subsequent years, this cohort formed into various groups, including pairs.

The next release was in February-March 1982 when five HY 1981 cranes were given their freedom. The nine released in 1981 had been confined together at four months of age, whereas the 1982 releases remained with their parents to prevent flock bonding in the hope they would integrate sooner with wild cranes. When the HY 1982 cranes were freed, they scattered in twos or as singles, and within six weeks four were dead from predation and accidents. Another would have died of wounds and starvation if it had not been retrieved and returned

to PWRC. Mitchell and Zwank (1987) speculated that rapid dispersal may have contributed to poor survival.

In October 1982, seven HY 1982 cranes were put into the pen where they spent six weeks. For several months, these juveniles stayed at the pen where as many as 15 wild cranes habitually fed. Later in winter, the HY 1982 cranes, with some HY 1980 subadults and wild cranes, fed at farms 6-9 km north of the refuge and roosted in a river marsh 4 km northeast of the pen.

Four HY 1983 juveniles were released in December 1983 after a month in the acclimation pen. Twenty or more wild and released cranes fed at the pen during January 1984. For three months after their release, this group remained near the pen, and after three years has not ranged more than 4 km.

Ten HY 1984 juveniles were released in December 1984 from the Ocean Springs acclimation enclosure. One young left the flock early in January 1985 and was seen with two wild cranes, but after three day's absence rejoined the flock at the pen. Nine cranes stayed near the acclimation pen during January, but by March ranged up to 5 km away, returning to roost near the pen. Two cranes that nest in a nearby territory were the only wild cranes that fed at the Ocean Springs pen.

In December 1985, four HY 1985 juveniles were released from the Ocean Springs pen. Within two days, one was killed by a bobcat *Lynx rufus*. One female paired with a wild male and left the flock after three months. The rest remained as a flock through 1985 and did not expand their range (Wilson 1987).

Three other HY 1985 juveniles, whose shipment had been delayed because of health problems and a hurricane, were released from the Gautier pen in December 1985. Within several days, these were joined by a HY 1983 subadult and the four remained close to the pen. In February 1986, they roosted occasionally in a borrow pit. A HY 1985 crane was unable to fly because of wrist stiffness and was returned to PWRC in January 1987.

Three young were released from the Gautier pen in December 1986. One died in February 1987. The other two joined a loosely organized flock of previously released birds.

## RESULTS

### Mortalities, Disease, and Accidents

Among 45 cranes released from 1981 through 1986, 26 are dead; two were returned to PWRC. Three of eight HY 1980 releases disappeared with no clues to their fate. Two others died of unknown causes near the pen and one was shot north of the refuge. The HY 1979 crane lived to be six years old, then died of a massive internal hemorrhage. In January 1987, -604 was found in a pasture nearly dead of head and neck wounds apparently inflicted by another crane. He was shipped to PWRC on 9 February where he soon died. A necropsy performed by the National Health Laboratory found a tumor in the neck. Among 15 Mississippi cranes autopsied by the laboratory, two released and three wild cranes contained carcinomas.

Within four months after release, four of the five HY 1981 cranes were dead. Two were killed by either a dog or coyote *Canis latrans*; one was killed by a vehicle on Interstate Highway 10; and another died of starvation due to parasitic infestation of the tongue. Only one survives; starving and hurt, he was caught at a local shopping mall and returned to PWRC. Head wounds suggested that he may have been attacked by a pair while living in their territory.

Two of seven HY 1982 cranes survived less than a year. One disappeared soon after release. Another, in poor condition because of nematodes in the proventriculus and intestines, was killed by a truck. Among five that survived into 1986, one in a weakened condition was caught and immediately died in April 1986. Necropsy at the National Wildlife Health Laboratory, Madison, Wisconsin, revealed a large abdominal tumor involving the spinal column. The first mortality (in 1987) of the four cranes released in 1983 was attributed to dog or coyote predation.

Among 14 juveniles released at the Ocean Springs pen during 1984 and 1985, seven were killed in the vicinity of the enclosure: one by a hawk or owl; four by bobcats; one by a dog or coyote; and one was accidentally killed by a M-44 coyote "getter." One HY 1985 juvenile (#854) that associated with a wild pair for some months returned to the Gautier pen and was killed eight months after release.

Among six juveniles released in 1985 and 1986 at the Gautier pen, two disappeared within six months and are presumed dead. One was returned to PWRC and three survive into 1987.

#### Predator Control

Predation occurring soon after release has caused the greatest number of deaths. Predator control was begun in 1984, and in 1986, a professional trapper was employed. Control devices include live traps, leg-hold traps, Conibear traps, snares, and M-44 coyote getters. The M-44's fire sodium cyanide into the mouth of an animal that pulls a scented bait with its teeth. The M-44's were considered canine-specific, but when a curious crane pulled the trigger on one, their use was suspended.

#### Associations and Breeding

Only two wild cranes visited the Gautier acclimation site during the first release (1981). The nine that were released remained as a flock for about four months, then split into smaller units. In November 1981, a female crane (#602) was the first to join the wild birds. During the winter, she paired with a wild crane; in the spring of 1982, she and her mate were seen regularly in a territory north of the refuge. Two small nests were found, but no eggs had been laid. In August 1983, #602 was found shot and dying near a primitive road adjacent to the territory.

In December 1981, another female (#607) joined some wild cranes, and by February 1982, she had paired with a wild male. The two were together into the spring of 1983, but after May 1983 she was not seen again.

In the summer of 1984, a HY 1982 crane (#616) became the surrogate parent and mate in a family consisting of a

wild female (later banded as #627) and her half-grown young. The wild male apparently had died earlier. In October 1984, HY 1979 crane (#608) replaced #616 as the mate and parent, and in May 1985, he and the wild female nested in her territory. Two eggs were laid, but the pair deserted the nest after a bulldozer inadvertently ran close to the nest. This was the first record of a released crane nesting and producing eggs. Unfortunately, #608 died in late December 1985.

A HY 1980 crane (#604) was seen from November 1981 through May 1982 with four others that had been released at the same time. He was not seen again until he showed up on 17 February 1983 at the Gautier pen with a wild crane. Later, #604 would remain missing for months; then would be found at places north and south of the refuge, with a wild crane.

During the 1985 nesting season, #604 associated with HY 1982 crane (#619) and a wild bird in an unoccupied refuge territory. In spring 1986, #604 returned to the territory with a wild crane. Several small nests were found there, but none with eggs. In January 1987, #604 was found in a pasture nearly dead of head and neck wounds, apparently inflicted by another crane. He was shipped to PWRC where he died.

Crane #606 (HY 1980) was observed occasionally from 1982 through 1985. In late 1985, #606 and two HY 1982 cranes (#621 and #623) were found in a rarely visited part of the refuge. Crane #606 spent the 1986 nesting season in a territory with #623; crane #621 was often seen in the vicinity. Later in the year, #621 died and #606 separated from #623 and is presently single. Crane #623 paired with a wild crane, and on 6 April 1987, hatched a chick, which subsequently died.

HY 1984 crane #640 left her cohorts at the Ocean Springs pen at less than a year of age and paired with a wild male. During 1985-1987, the pair stayed 6-8 km north of the release site. The pair remained together until 11 March 1987 when she was found with radio-tagged wild crane #632. The new pair nested in May 1987, and produced two eggs; the one viable egg was destroyed by a predator.

Four of the HY 1984 released cranes were usually together in the Ocean Springs area. Two (#643 and #644) formed pair bonds, and nested in April 1987 near the Ocean Springs release pen and produced two eggs.

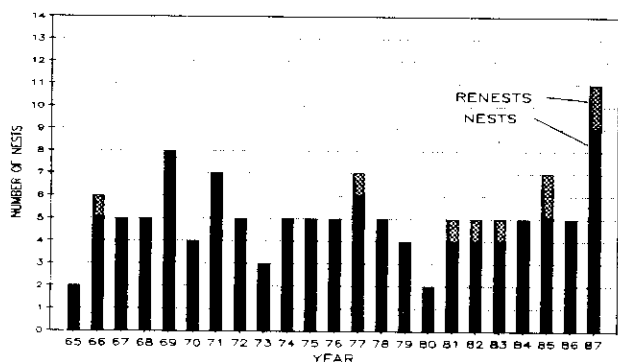
In early 1986, a HY 1985 juvenile (#854) joined a wild pair and associated with them at their territory and roost. Probably evicted from the territory, he appeared in March 1986 at the Gautier pen.

Three pairs involving released cranes moved into territories in the spring of 1986: HY 1980 crane #604 paired with a wild crane; HY 1980 crane #606 paired with HY 1981 #623 southeast of the Gautier pen; and HY 1984 crane #640 paired with a wild crane north of the Ocean Springs Unit. No eggs were produced.

In 1969, Valentine with others found eight nests, the highest number found during 1965-1986. This record was broken in 1987 with nine nests, exclusive of renests (Figure 2). Among nine nesting pairs found in 1987, three were formed by a released crane and a wild mate, and one pair

was composed of male and female released cranes. One 5-year old, one 4-year old, and one 3-year old paired with wild mates; and two 3-year old's paired together.

Two territories used by pairs with released cranes were unoccupied territories; one pair usurped part of an occupied territory; and one was a new nesting site. Two pairs hatched a switched egg (from PWRC) that replaced non-living eggs in the nest. One of these chicks at 85 days of age, and fledged, was seen with its parents (#634 and wild mate) on 5 August 1987.



**Figure 2.** Number of active Mississippi sandhill crane nests found each year in Jackson County, Mississippi (1965-1987).

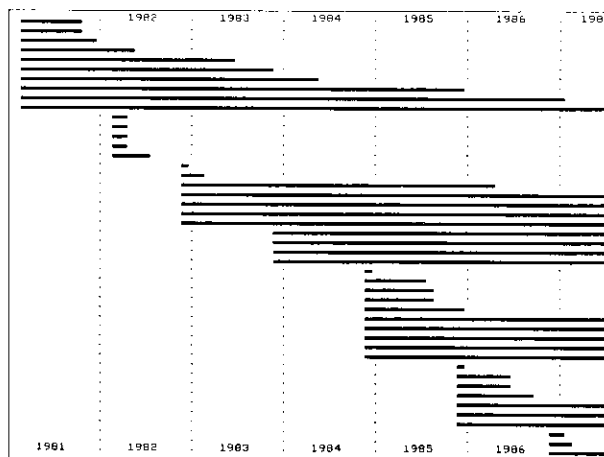
### Survival

Among nine HY 1980 cranes released in 1981, one survives in the wild at age seven years (1987). None survives among the five HY 1981 cranes released in 1982, except the one returned to PWRC. Four of seven HY 1982 cranes are living at five years. Three of four HY 1983 cranes survive at four years of age, and five among 10 HY 1984 are still alive at age three. Seven HY 1985 were released in 1985 and three survive. One of three released in 1986 survive at age one year in the wild; one was returned to PWRC. Among a total of 45 that were released, 17 survive in the wild (see Figure 3).

### Roosting

The earliest known and most frequently used roost is located in the Bluff Creek (a tributary of the West Pascagoula River) marsh. In recent years, seven other main roosts have been found; more temporary roosts include several savannas and impounded road ponds.

The nine cranes released in 1981 roosted in a savanna southwest of the Gautier pen during the first several months. At this time, only two wild cranes fed at the acclimation pen, and the released birds did not follow them to a roost. When more wild cranes began coming to this pen, the released cranes followed the wild birds, particularly to the Bluff Creek marsh, and to a borrow pit 1.5 km east of the Gautier pen. The 17 cranes released at the Ocean Springs pen in 1984-1985 roosted for several months inside and outside the acclimation pen. The wild cranes at Ocean Springs and some released cranes now roost mainly at an abandoned catfish pond 3 km north of the refuge.



**Figure 3.** Mortality and survival of 45 released captive-raised Mississippi sandhill cranes on the Mississippi Sandhill Crane National Wildlife Refuge, Jackson County, Mississippi (1981-1987).

### DISCUSSION

Experimental releases have been made in other places in the U.S.A. with little or no acclimation. Fourteen hand-reared five-month old Florida sandhill cranes died within a few months after being released. Eighteen pen-reared Florida cranes of various ages were released at Paynes Prairie, Florida. Though imprinted on humans, a few survived for some time, but only a parent-raised female that associated with wild cranes lived several years (Nesbitt 1978).

Successful releases into migratory populations may be difficult because the young must quickly meld into the native population so they can be led to the wintering grounds. At Grays Lake, Idaho, seven among 11 captive parent-reared young survived until migration time; but only one female that joined a wild male survived migration (Drewien et al. 1981).

With minimal human contact, but after elaborate preparation by biologists at the International Crane Foundation, five hand-raised juveniles (at age 3.5 months) were released in the fall of 1985 at a staging area on the Necedah National Wildlife Refuge, Wisconsin. The juveniles soon joined wild cranes and migrated; four returned in the spring to the release area (Horwich 1986).

The Mississippi juveniles spent a month or more in an enclosure where they acclimated to the environment and formed social bonds. The acclimation pens and surrounding crop fields provided home bases and winter feeding stations for both wild and released cranes. Bobcats, coyotes, and dogs caused the greatest mortality; predator control and habitat improvement have high priority in management.

The released subadults can survive on natural foods found in the forests and savannas but supplemental food is provided in winter. The native and released cranes do not usually return to the crop units until cold weather (late October to mid-November). Two or three may have died

or suffered from starvation, but this was precipitated by internal parasites or injuries.

Social bonding during acclimation keeps the cranes from dispersing rapidly; integration into the wild population enhances survival. Mated pairs and pairs with young do not usually tolerate close associates at any time of year, but other cranes often follow pairs and families to roosts and winter feeding grounds. Flights from feeding grounds to roosts were usually initiated by wild males, with the others following in a loose flock breaking up into smaller units, which usually flew in the same direction, but sometimes in several directions.

Because of low natural recruitment, there were few non-breeding cranes prior to the releases. After releases had been made for several years, loose assemblages of unmated wild and released cranes formed. From these aggregations, bonding and pairings were made. The acclimation sites and the various crop units were assembly points where integration could take place. Our observations suggest that adults who have lost their mates quickly remate, and females find mates more quickly than males. Nesbitt and Wenner (1987) in Florida thought that males re-paired more quickly.

Parent-rearing of captive young requires a stable of pairs to lay eggs and incubate. More young can be produced through multiple clutching and by hand-raising, which requires intensive care. We believe that hand-raised cranes can be released successfully into a non-migratory population if the juveniles spend sufficient time in an acclimation pen and integrate into a cohesive flock.

Another method should be tried: place the captive-raised young in an acclimation enclosure perhaps a month before they can fly; then allow them to fly at will out of the pen. This method would eliminate brailing which requires handling, probably weakens flight muscles, and hastens wear of wing feathers.

#### Release Period

Winter was considered the best time for the released cranes to integrate into the wild population. Some arguments for winter releases are: 1) winter releases shorten the handling time at PWRC; 2) there is a greater concentration of wild and released cranes at the acclimation site; and 3) cranes are most sociable at this time.

An early spring (late February or March) release, when breeding pairs go to their territories, may have advantages: 1) spring coincides with the abandonment of the young by their parents; 2) the juveniles are a few months older, thus stronger, and better flyers; 3) the released juveniles may

join the non-breeding groups; 4) the non-breeders tend to remain on the refuge; and 5) predation may be less severe in spring.

Tameness can be hazardous for released birds, particularly if they are a hunted species, but a degree of tameness can be a positive attribute. In Mississippi, farmers who had cranes on their lands told how cranes fed in their cattle feed lots and pastures. The cranes became "their birds" and were protected. The released cranes appear as wary as the natives. The excessively "tame" cranes that ended up in someone's yard or a shopping mall were determined later to be sick or injured.

#### Habitat Management for Released Cranes

All completed habitat improvement has an immediate and future value for the released cranes in providing breeding and feeding grounds. The removal of trees and shrubs to enlarge and create grasslands reduces bobcat habitat, and may lessen predation. Some roosting grounds on the refuge have been improved and others created through water control measures. Because most predation has been at night near the pens, it may be prudent to construct roosting ponds within or adjacent to the acclimation pens where the cranes would be more secure from mammalian predators.

#### CONCLUSION

The success of the release program depends on whether the released cranes survive and raise young. One male, at six years of age and mated to a wild female, produced eggs in 1985. In the spring of 1987, five released cranes became breeders, which gives cause for delight and optimism. Attrition has been fairly high, but not excessive. With a greater yearly supply of young to be released, and continued intensive management, we believe success is forthcoming.

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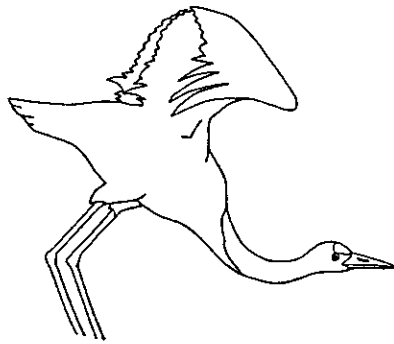
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CHAPTER 13  
CAPTIVE CRANES





## THE ROLE OF CAPTIVE BREEDING IN THE CONSERVATION OF CRANES

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### ABSTRACT

Captive breeding plays a valuable supporting role in field programs for the conservation of cranes. This paper begins with a review of previous directions in captive research efforts. Research on captive breeding biology and behavior has useful applications to field research. Examples of data collected in captivity that may guide or supplement field studies, and examples of field studies that have enhanced captive management are discussed. Among zoos and other captive breeders, propagation strategies are shifting from management of individuals to management of populations. Studbooks and species survival plans are being developed for half of the crane species. As more institutions participate in these programs, it is becoming possible to attain the level of population analysis critical to long-term preservation of genetic variation. As a result, long-term management of healthy, viable captive populations is becoming realistic. We are also reaching a level of management at which surplus birds are becoming available for reintroduction efforts. There is a need to increase cooperation among the various groups involved in crane conservation including field and laboratory researchers, government officials, educators, land managers, and captive breeders. Reintroduction programs especially depend on a multidisciplinary approach. Research efforts in captive collections are developing reintroduction techniques, with a focus on rearing method, age of release, and method of release.

### INTRODUCTION

The protection of habitats and the reduction of threats to wild cranes are the two most important approaches to the conservation of endangered cranes. Although much has been accomplished, it must be recognized that some efforts to conserve wild flocks may fail due to pressures from land development, human population increases, hunting, or from political instabilities. For example, the 1,350 Siberian cranes *Grus leucogeranus* in the eastern flock are highly specialized in their feeding habits and depend on a delicate natural balance at Poyang Lake (Archibald 1985). The existence of this flock may be threatened by a dam proposed for the Yangtze River. Extensive protection work is in progress at Poyang, but pressure for the dam and its benefits may exceed the ability of conservationists to intervene. If erected, the dam would also likely result in the reduction of siltation at the river's delta and thus lead to the erosion of the major wintering habitat of the red-crowned crane *G. japonensis* at the Yancheng Nature Reserve (G. Archibald pers. comm.).

Due to these and other threats, captive breeding efforts serve a valuable supporting role to field efforts. Well managed captive populations are a valuable "insurance policy" against extinction in the wild (Flesness 1977; Foose 1977; Soule 1980; Carpenter and Derrickson 1981). If we were to wait until it appeared likely that field efforts would fail, captive breeding would also be likely to fail due to difficulties in obtaining adequate genetic stock without aggravating pressure on the declining wild populations or due to tense political situations. Currently our efforts to

establish captive populations are developing hand-in-hand with field efforts, and clear benefits are gained for conservation programs for wild cranes.

Not all captive breeding projects are suitable and new efforts should be carefully evaluated before they are initiated. These programs can be very costly, and limited resources may be better applied to field efforts. It is important that captive breeding does not function as an anesthetic, creating a false illusion that all is well. If captive efforts are initiated, they require a strong commitment to insure that they are well-conceived, well-managed, and integrated into comprehensive species recovery programs. These programs may need to include habitat protection and restoration measures, plans for reintroduction, scientific monitoring, public awareness campaigns, and legislative action. They should have the full support of the government of the species' country of origin (Imboden 1987).

A careful examination of captive breeding programs demonstrates the value of captive propagation as a conservation strategy. Captive breeding programs for cranes benefit conservation of these species in their original wild habitats through: (1) public education; (2) training programs for field researchers; (3) information provided on breeding biology, disease, and behavior; and (4) the development of release techniques and the successful release of captive produced birds. Captive breeding programs insure the development of genetically viable, self-sustaining captive breeding populations. This safeguards the species against extinction and insures that the birds eventually released are representative of the original wild forms.

This paper examines progress made in these areas. This

information should provide useful guidelines for captive managers developing existing programs and for the initiation of new efforts. Field researchers are provided with information on captive breeding to facilitate the development of cooperative efforts.

#### HISTORY OF CAPTIVE BREEDING

Due to their size, magnificence, and beauty, cranes have won a special place in human hearts. Cranes have a long history as symbols in human culture (Topsell 1972). Human desire to understand and preserve these birds, and sometimes the simple desire to have contact with them, have resulted in a relatively long captive history. There are records of cranes being bred in captivity in Qiqihar, China for at least 190 years (Sun this proceedings). All fifteen species have been kept in captivity over the five continents where they are native.

Records on successes and problems have been kept over the years, but research on husbandry and captive propagation techniques has intensified in the past 10 to 20 years. The major areas of research have included nutrition, facility design, behavioral management, fertility improvement, incubation, rearing techniques, health care, genetic management, and reintroduction.

#### INITIATION OF CAPTIVE BREEDING PROGRAMS

Carpenter and Derrickson (1981) developed valuable guidelines for initiating captive breeding programs. Important factors to consider include:

- (1) the probability of extinction of the species;
- (2) the effectiveness of management efforts in the wild;
- (3) the potential to address basic and research management questions;
- (4) the potential for successful reintroduction;
- (5) the applicability of techniques developed to other endangered species;
- (6) the availability of captive stock; and
- (7) the availability of facilities, staff, and operating funds to initiate and sustain a breeding program.

These criteria should be applied to the development of programs for a particular crane species or for a geographic region. Serious captive management efforts are underway for whooping *Grus americana*, red-crowned, Siberian, white-naped *G. vipio*, hooded *G. monacha*, wattled *Bucconas carunculatus*, and Mississippi sandhill cranes *G. canadensis pulla*.

No institution can or should attempt to establish a viable captive population single-handedly. It is dangerous to concentrate all of the individuals in one location due to potential threats from disease or natural catastrophe. Cooperation among several participating institutions is critical. Many "new" centers are actually new participants in existing programs.

The initiation of smaller centers housing a few individuals for educational purposes can also be justified and is discussed next.

#### EDUCATIONAL VALUES

Captive cranes have contributed to the conservation of their wild counterparts through several types of educational programs. Display birds have helped to generate the broad public support that is critical to the funding of conservation programs and to the support of legislation. Significant contributions of time and money have been made because people were inspired by the beauty and grace of the cranes during visits to captive centers. Although much has been accomplished by slide shows, lectures, and films, seeing a bird firsthand has tremendously greater impact than images or words can convey. To appreciate the truth of this, you need only watch the eyes of a child when first confronted with a living crane.

A well run display program does not merely exhibit these birds but takes advantage of their impact on people to communicate important issues on endangered species, habitat values, and wetland conservation. The needs of humans, cranes, and other wildlife are inextricably intertwined with the quality of these ecosystems. Through the visitor experience, a bond can be created between human and bird, linking the survival of cranes to the quality of our own lives.

Particularly important can be the display of live birds near their threatened habitats. Too often the people threatening the cranes and their wetlands are unaware of the value and significance of the birds. These programs can create a feeling of stewardship for the birds and greatly enhance chances for successful management.

The excellent educational program at Zhalong Nature Reserve in China is visited by over 40,000 people annually. The flock of display birds and the educational facility enable these visitors to view live cranes, learn about the wild birds, and learn about the effects of human activity on the environment. These displays have also helped to control visitor activities at this popular place, reducing negative impacts on the wild birds and their critical habitats.

Educational programs centered around communicating important conservation principles are developing in several countries. A few cranes, preferably captive-born or rehabilitated, non-releasable birds, will be displayed to enhance the impact of these programs. These places include Poyang Lake Nature Reserve (Siberian crane) and the Yancheng Nature Reserve (red-crowned crane) in China, Thailand (eastern sarus crane *Grus antigone sharpii*), and South Africa (Stanley *Anthropoides paradisea*, gray crowned *Balearica regulorum*, and wattled cranes).

Captive cranes can also be highly useful in training programs for field conservationists. ICF's foreign training program has assisted in developing field studies and conservation programs in other countries. Foreign researchers are invited to visit ICF for three-month internships or for four-week fellowships. Training is provided in aviculture, education, habitats, or general conservation. Captive birds provide the opportunity for studying crane behavior, reproduction, and handling and banding of cranes. The skills learned are then taken back to the countries that the

cranes inhabit and can be applied or shared to enhance conservation efforts.

#### CAPTIVE RESEARCH VALUES

Unless information collected in captive studies is applied to conservation in the wild, we are only realizing a part of the value of our work. Data collected in captive research studies have already proven useful to field biologists studying cranes. For example, observations on eggs floated in water to determine whether the embryo is viable (alive and healthy) have generated data that enable field researchers to estimate the age of eggs of wild cranes. Techniques developed for sexing cranes by examining chromosomes cultured from feather pulp or blood can enable field workers to sex birds that have been handled for banding (Sasaki et al. 1968; Takagi et al. 1972; Sasaki and Takagi 1981). Also, behavioral data collected in captivity, such as signs of pairing, have helped field researchers to interpret correctly behaviors observed in the field (Voss 1976; Masatomi 1983).

Disease research on captive cranes can enhance conservation efforts in the wild. This information may become critical as populations become smaller and more concentrated. Flocks of special concern are the wintering population of the Siberian crane at Poyang Lake in China and Bharatpur in India, and the winter feeding flocks of the red-crowned crane in Hokkaido in Japan. The National Wildlife Health Center (NWHC) and the Patuxent Wildlife Research Center, with assistance from ICF and research laboratories, have conducted research on diseases affecting cranes such as inclusion body disease of cranes, avian tuberculosis, eastern encephalitis virus, Newcastle's disease virus, avian cholera, avian pox, botulism, parasites, and toxins. The NWHC has generously assisted foreign researchers with disease concerns.

Avian tuberculosis has caused significant mortality in the flock of whooping cranes at Gray's Lake, Idaho. Researchers have been able to analyze and diagnose this disease based on research in captivity on pathology progression of the disease, and antemortem diagnostic techniques. Captive research is currently in progress on treatments (Montali et al. 1976; Montali 1978; U.S. Fish and Wildlife Service unpublished data).

In the future, release of captive-produced, radio-tagged birds may enable us to identify unknown staging grounds and migration routes. This information would help focus conservation efforts and insure the maximum success from limited manpower and resources. Although capturing and marking wild birds would be simpler, this action may not be advisable or permissible in certain countries.

Work by field biologists has also been of great assistance to captive managers. Observations collected on wild broilgas *Grus rubicunda* indicate that these cranes breed during the Australian monsoons. Consequently, the first captive breeding of this species outside of Australia occurred at ICF, only after we began to use sprinklers to simulate these rains.

Data collected on wild populations have been invaluable in planning release studies. For example, information collected on wild sandhill cranes has helped researchers at ICF to determine where to place release pens and what food items to offer to isolation-reared chicks (Horwich pers. comm.).

We are currently hoping to determine whether a virus that caused die-offs in two captive crane collections is present in wild cranes. Captive breeders now spend large amounts of time and money on screening birds. If the virus is already prevalent in the wild, this work might alter some of our management practices for this disease. The concern over introduction of this disease to wild birds would be reduced, but concerns over captive management would still need to be addressed. This information might also help us to understand the source and incidence of this disease. We hope to enlist the help of field researchers to obtain blood from cranes captured for banding.

#### PRESERVATION OF GENETIC DIVERSITY

The emphasis of captive breeding programs is changing. Previously our goals were to maximize reproduction due to low numbers of captive cranes. Although techniques still need refining, cranes can now be bred fairly easily if they are provided with a secure territory, a compatible mate, proper nutrition, and health care. The goal of captive propagation, however, should not be simply to keep and breed cranes. If we are to attain our goals of establishing viable species banks, we must insure that captive flocks are managed to represent adequately the original wild forms.

Preservation of genetic diversity maximizes a species' ability to adapt to changes in its environment. With increasing alteration of environments by human encroachment, preservation of genetic diversity can make the difference in a species' ability to survive the changes. Adaptability is particularly critical to captive birds destined for release into new or altered habitats.

Propagation strategies are therefore being shifted from the management of individuals to the management of populations. This shift is necessary in order to achieve our goals of establishing self-sustaining captive breeding populations. The goal of population management is to maximize the preservation of genetic diversity within the captive populations. The techniques developed may also need to be applied to small remnant populations in the wild.

To preserve genetic diversity, pairings and reproduction must be carefully planned. Detailed records on the history of each bird are necessary. Studbooks are the basic tool for these management decisions. Studbooks contain information about the sex, birthdate, sire, dam, locations, date of transfers, and death date. Other helpful information includes additional identification numbers, inbreeding coefficients, and captive or wild origin.

Early efforts to set up studbooks faced difficulties. Many institutions were originally unwilling to participate because of the work involved in digging through old records. Another major problem was that many times the necessary information was never written down. Sometimes it became

necessary to remove certain individuals from the managed population because of lack of data. Some missing data, however, can be estimated fairly accurately. Estimations should always be on the conservative side. For example, if there is a possibility that two individuals are siblings, it is best to assume they are and to assign them the same parents. As information on individual animals is carefully recorded and applied to their management, the likelihood that captive breeding efforts will significantly contribute to the survival of these species is greatly increased.

International studbooks are coordinated by Peter J. Olney, Editor of the *International Zoo Yearbook*, an organ of the Zoological Society of London. In addition, many areas are developing regional studbook systems including North America, Britain, continental Europe, and Australia. Many times regional studbooks are later expanded to international status. Regional studbooks are advisable when there are large numbers of individuals within a given region or the data are complex. Sometimes captive populations are large enough that it is advisable to manage individuals within different geographic areas as subpopulations. Periodic exchange of individuals between these subpopulations and the introduction of new bloodlines from the wild support the preservation of genetic diversity.

There is a need for increased international cooperation in studbook management. It is hoped that countries that hold many valuable, endangered species in captivity will

commit their energies to insuring the survival of these species by initiating or participating in studbooks. Assistance is available through ICF to anyone wishing to become involved in studbooks for cranes, or through the American Association of Zoological Parks and Aquariums (AAZPA) for studbooks in general.

Once a studbook is compiled, it should be carefully analyzed genetically and demographically and a masterplan developed for the species as a whole. This is the concept behind the Species Survival Plans (SSP) of the AAZPA. Through this type of management, our goals of preserving species become realistic. Several other countries are developing programs similar to SSPs. Table 1 lists the current studbooks and management programs for cranes. Details on the management of Species Survival Plans can be obtained through the AAZPA Conservation Coordinator, Minnesota Zoological Gardens, 12101 Johnny Cake Ridge Road, Apple Valley, Minnesota, 55124, USA.

A well designed masterplan should contain annual breeding recommendations for each animal and institution. Management protocols should be developed that pool knowledge on problems and successes in husbandry and propagation and should address areas such as diet, facilities, behavior, reproduction, management of fertility, incubation, chick rearing, and health care. These protocols are a valuable tool in training staff for new centers and can avert duplication of efforts and repetition of mistakes. The

Species	Program	Coordinator	Institution
Whooping crane	Studbook/management program	Claire Mirande	International Crane Foundation, U.S.A.
Red-crowned crane	International studbook and Japanese management program	Etsuo Narashima	Tama Zoo, Japan
	North American management program	Claire Mirande	International Crane Foundation, U.S.A.
	North American regional studbook European management program	Scott Swengel Rob Belterman	International Crane Foundation, U.S.A. Rotterdam Zoo, Netherlands
Black-necked crane	Chinese regional stockbook	Zhao Qingghou	Chinese Association of Zoological Gardens, China
Siberian crane	International studbook	Vladimir Panchenko	Oka State Nature Reserve, U.S.S.R.
	Chinese regional studbook	Zhao Qingghou	Chinese Association of Zoological Gardens, China
White-naped crane	International studbook and North American management program	Christine Sheppard	New York Zoological Park, U.S.A.
	Japanese management program	Kazuaki Nippashi	Saitama Children's Zoological Nature Park, Japan
	European management program	Peter Mulhing	Tiergarten der Stadt Nurnberg, West Germany
Hooded crane	International studbook Japanese management program	Bruce Bohmke Kazuyoshi Ito	St. Louis Zoological Park, U.S.A. Tama Zoo, Japan
Wattled crane	North American regional studbook	Fred Beall	Baltimore Zoo, U.S.A.
Blue crane	North American regional studbook	To be determined	Dallas Zoo, U.S.A.
West African crowned crane	North American regional studbook	Susan Haeffner	Denver Zoo, U.S.A.

**Table 1.** Current management programs for crane species in captivity.

masterplan should also identify research that can improve management of the species.

Numerous problems are faced in preserving genetic diversity. In the past there have been difficulties with inbreeding, hybridization, over-representation of certain pairs, lack of breeding in valuable founders, insufficient data on which to base decisions, and inadequate space in zoos to maintain minimum viable populations. For captive management programs to succeed, high levels of cooperation are needed. For example, a zoo may be asked to give up a favorite individual or to stop breeding a prolific pair.

Significant progress is being made on population analysis techniques and masterplan development. Several major zoos have hired population geneticists; others are setting up cooperative programs with universities. Training programs in population genetic principles have been developed for zoo managers.

#### RELEASE EFFORTS

The successful establishment of species banks can be an important component of crane conservation strategies. It must be remembered, however, that our goal is not just to preserve the species, but to insure its existence in its native habitats. The true test of captive programs will lie in our ability to return cranes to the wild.

Captive produced young can be released to bolster the numbers in small remnant populations, to reestablish extirpated populations, or to introduce new populations (Carpenter and Derrickson 1981). The type of release selected will depend on complex factors.

For most crane species, large scale reintroduction efforts are premature. The factors involved in the original declines have rarely been determined and eliminated. It is also too early in most of our propagation programs to produce sufficient numbers of young to establish viable populations in the wild. To establish self-sustaining captive populations, the number of captive cranes should be rapidly expanded to carrying capacity. In this way significantly large numbers of young can be produced to support release efforts. Future prospects for cranes look bright. By multiple clutching we should be able to raise four to six chicks per pair per year.

Initiation of some reintroduction studies, however, can help to further our conservation objectives. It is important to develop techniques for producing young that are behaviorally suitable for release to the wild. These studies can be conducted with common species and with genetically surplus young from well represented captive pairs. Additional benefits can be gained because these studies are attractive to the public and focus attention on critical habitats and key conservation issues. Reintroduction efforts depend on close cooperation among people in various disciplines. Field researchers are needed to determine the status of the wild cranes and to study and identify suitable release sites. Protective measures for the land and the birds need to be set up and enforced by refuge managers and government officials. Major education campaigns are often needed to promote public support and to prevent or at least reduce the human problems that contributed to the decline or local extinction of the species.

After progress has been made in these areas, captive breeders may then work to supply eggs or to rear young in captivity that are behaviorally prepared for release to the wild. Captive researchers must then work closely with field researchers to release the birds and to monitor their success after release to the wild. The reintroduction program for the eastern sarus crane in Thailand is an excellent example of a comprehensive reintroduction program (Mirande 1985; Harris 1987).

The development of reintroduction techniques has become one of the major research topics in captive collections. Exact and detailed research is focusing on rearing methods, age of release, and methods of release. Characteristics of birds associated with successful releases are the ability to forage effectively, fear of predators, fear of humans, ability to socialize with wild conspecifics, and ability to produce young with conspecifics at sexual maturity.

Field experiments on reintroduction can be conducted that function without assistance from captive breeding programs. A second experimental flock of whooping cranes has been established in the western United States by cross-fostering young under sandhill cranes. Cross-fostering has the advantage that eggs can be placed directly into the nests of wild foster parents. These chicks are raised in their new environment and do not have to be released at a later date. These eggs can be produced in captivity or pulled from the nests of wild cranes. Although there are currently 22 birds in this flock (Pratt 1987), no pair formation has been observed. This can be partially attributed to wide dispersal of the whooping cranes and a skewed sex ratio, but sexual imprinting on the foster parent species may be involved.

It is therefore important to conduct further research on cross-fostering and sexual imprinting. Many complex factors may be involved such as species differences, reversibility of imprinting depending on length of contact with foster parents, and the relative numbers of conspecific and foster-species birds present at the release site and available as potential mates. Cranes have a long generation time and carefully controlled experiments will be difficult. Variability between species makes extrapolation from other avian species difficult (Klopfer pers. comm.). Captive collections, however, offer special research opportunities. There are cross-fostered birds present in several collections. By setting up mate preference tests we will likely obtain data that can be highly valuable in guiding future management efforts even if the data are not suitable for statistical analysis. Observations in Japan on a red-crowned crane raised by a pair of white-naped cranes indicate that strong sexual imprinting on the foster parent species may occur (Asakura pers. comm.; Sugita pers. comm.). ICF has initiated research on cross-fostering and we encourage other centers to assist in collecting data.

If cross-fostering does not work, then captive breeding provides opportunities to develop alternative rearing techniques. These techniques will also be important when a foster species is not available in the wild, or when management strategies call for release of captive reared young. Significantly more work has been achieved in the

development of reintroduction techniques for cranes than for most other species.

Several successful releases of young reared by cranes in captivity have been conducted. Forty-five Mississippi sandhill cranes reared at the Patuxent Wildlife Research Center in Maryland have been released to the wild by acclimating them in community flight pens. After four to six weeks, wing brails are removed and the young allowed to fly free. Supplemental feedings are provided. Nineteen birds have survived, and in 1987 one of the released birds successfully raised a chick. At least three others are paired and have established territories (McMillen et al. 1987; Valentine this proceedings).

In Hokkaido, Japan, a technique has been developed which may be applicable to future releases. Wild caught male red-crowned cranes were pinioned and placed in large open pens. Wild females flew in and paired with these birds. Eventually the young left with the wild cranes, but the females stayed within the general vicinity (Konrad 1976, Archibald pers. comm.). At the Zhalong Nature Reserve in China, captive pairs of red-crowned and white-naped cranes are released each spring into the local marshes. The birds become territorial, nest, and produce young. Over the winter, the young are housed in pens with their parents. The following spring the trio are released and the young leave to join the wild flocks. The adults are recaptured and housed in captivity for the winter. Early clutches are pulled to supplement captive breeding efforts. The parents are extremely aggressive to humans during these encounters, a trait which may endanger both unsuspecting people and the birds. With sound education and protection programs, however, captive pairs allowed to produce young in the wild environment can augment the numbers of the wild populations (Archibald pers. comm.; Xu et al. this proceedings).

In 1982, two sandhill cranes reared at ICF with the use of puppets and visual barriers were released into the wild. In 1987 one of these birds was observed with a mate on its wintering grounds in Florida (K. Archibald and G. Archibald in press). Special isolation-rearing facilities have been built and tested on several species at ICF. Red-crowned and Stanley cranes raised by this method were fearful of humans. Mixed results were obtained for Siberian and sandhill cranes (Swengel and Mirande unpublished

manuscript). In 1984 and 1985, Robert Horwich refined the techniques to include stuffed models, taped vocalizations, and a costumed parent. In 1985, sandhill chicks were brought to a release site prior to fledging and taught by the costumed parent to forage on native foods. They were locked into small shelters nightly until they could fly well enough to avoid predators. Through application of these techniques, five young were released into the wild and four were observed back in Wisconsin the following spring (Horwich 1986). The behavior of these cranes is not significantly different from their wild counterparts, and the distance at which they fly away from humans is equal to the distance for wild birds (Wood in press).

## CONCLUSIONS

Historically, conservation programs for a single species have often functioned independently of each other. Conservation programs are likely to proceed more smoothly and to achieve greater success if they are integrated and designed to support overall goals. Protection of habitat and reduction of threats to wild birds are the most critical components of conservation strategies. Captive breeding has been demonstrated to play a valuable supporting role in these efforts.

Captive breeding strategies are undergoing a dynamic evolution and prospects for enhancement of conservation objectives are very good. Current captive efforts are benefiting conservation through well designed educational programs. Research efforts on captive and wild populations are being integrated to generate information that applies to management in both areas.

Cooperation among various captive facilities is resulting in the development and implementation of sound genetic and demographic management strategies. Consequently, the prospects for long term maintenance of captive populations representative of the original wild forms are excellent. These "species" banks will insure the survival of cranes should some conservation efforts in the wild fail, an unfortunate possibility due to human pressures and political realities. Should such losses occur, the potential for the eventual return of these crane species to their former habitats is being insured through the successful development of reintroduction techniques.

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## A RECORDS SYSTEM FOR A CAPTIVE CRANE FLOCK

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### ABSTRACT

Crane record keeping systems have been evolving at the Patuxent Wildlife Research Center (PWRC) since 1966 and at the International Crane Foundation (ICF) since 1974. The system we present here, a hybrid of the two systems, has been reorganized to promote easy access of information and to limit redundancy.

The system includes 12 to 14 records covering demographic and medical events for the individual and its mate, 10 to 12 daily working records, 9 to 10 summary reports, and 9 visual aids for tracking the chronology of adults, eggs, and chicks through the breeding season.

As presented, the system can be used as a manual data entry and filing scheme, but it was also designed for easy conversion to a computerized relational database management system.

### INTRODUCTION

Because half of the world's cranes are in danger of extinction, the wise management of captive flocks becomes increasingly important. Fundamental to good management is the keeping of detailed records of important life history events and genealogy. The knowledge of family relationships is essential to genetic management in long term captive breeding programs.

The need for a complex computerized records system for general use by many institutions was identified by the Committee on Laboratory Animal Records (1979). To facilitate the keeping of good records on animal colonies, several systems for efficiently maintaining health, productivity, and vital records have recently appeared (Seal and Makey 1975; Brown 1975). Most widely used in the avicultural community is the computerized International Species Inventory System (ISIS) designed to promote uniform reporting of basic demographic information for individual specimens throughout the network of subscribing institutions (Seal et al. 1976, 1977). As of September 1987, 236

institutions participate in ISIS (U. S. Seal, pers. comm.). This system provides a computerized dBase III Plus (Anonymous. 1986 *unpublished*. Learning and using dBase III Plus. Ashton-Tate.) management scheme which is probably suitable for the operation of most animal collections characterized by a few individuals of many species and where a computer with sufficient memory capacity is available. Computerized records systems are also available which can accommodate detailed information on productivity, health, and many life history events (Sciabbarrasi and London 1974) and can be used for management of animal health records (Castleberry et al. 1966; SNOMED 1976, 1977).

Because of our peculiar needs at PWRC and ICF, none of the systems cited above is fully adequate. Our colonies are characterized by few species and very few breeding adults. The breeding birds in our colonies are often of endangered species or subspecies, hence the need closely to monitor all pertinent aspects of growth, health, and productivity for each individual.

The system we present here is a hybrid of the best features of the systems that were developed over two decades at our separate institutions. The system can be used directly in the management of other crane colonies and can be modified for use for other animal colonies as well. It is designed for limited redundancy, for ease in manual filing and retrieval, and for ease in conversion to automated processing via relational database software.

Because of space limitations, we present here only a few examples of the most complex forms. Examples of all forms in the complete system can be obtained from the senior author. For the remainder, we give either a list of the col-

umn and row headings, or a summary of the purpose and contents of each form. We also provide details on the use of the system including filing instructions and a table of appropriate responses for a sample of life history events. We indicate, for example, what records are created or modified when an egg is laid or a bird dies.

Several conventions were employed in designing the records system. To limit redundancy and for ease in record retrieval, we use whenever possible the individual identification number (ID, the leg band number in colonies) as an index to all records where the specimen appears as an individual. In our system, the ID also indicates the hatch year, so records filed by ID are also in chronological order. Usually this access number, the ID, and other filing instructions appear in the upper right corner of each form sheet. To avoid confusion in reporting reproductive success, we count all chicks reaching 70 days of age (hatch day is day 0) as fledged. In naming records, we usually supplied descriptive titles. For records with lengthy titles, we gave abbreviated titles (for example, Weekly Report) which were more helpful for daily use.

## THE RECORDS SYSTEM

The records system is presented schematically in Figure 1. This figure serves as an index to the narrative on each record. The alphabetical designator of each record in the figure can be used to more easily locate the record in the text.

In Figure 1, the records are arranged from left to right chronologically by life history events. Individual and pair records are near the top followed by daily working records, summary reports, and visual aids. Most of the records contain information about individual birds. Some, however, give readings from machines, and one, the Annual Time Line, provides a visual display of all regularly scheduled husbandry activities and the general phenology of the breeding season. Most of these records follow a highly structured format, an exception is the Daily Log. In all, 40 to 45 records are treated in the narrative.

## INDIVIDUAL AND PAIR RECORDS

### A Individual Record

This record (Figure 2) provides an overview of the life of an individual crane as well as an index to all other records where this bird appears as an individual. Details of various phases of the crane's life are kept on more specific records discussed later. The Individual Record, however, includes summary information concerning everything from rearing conditions to physical and behavioral peculiarities and pens occupied. This record is filed by species and ID. Records of living stock are filed separately from dead or dispersed birds.

### B Egg Card

The Egg Card is used to record incubation conditions and locations, and to record embryo condition for eggs that fail

to hatch. For eggs mechanically incubated, the back of the Egg Card (Figure 3) can be used to record daily weights which are plotted against a normal weight loss curve so adjustments in the incubation conditions can be made. At ICF, notes are also made of the hatching process (Hartman et al. 1987). Egg cards are filed by year, species, and dam or chick ID.

### C Hand-reared Chick: Daily Log

Hand-reared chicks are weighed and inspected daily. Column headings on this form are, from left to right: date, age, weight, weight change, treatments, general comments, and initials of caretaker. This record is a running log on the progress of each chick. Weight gain is emphasized in this record because of the prevalence of toe and leg deformities associated with too rapid growth (Carpenter 1977, 1986). Weight is plotted against a normal weight change curve for the species and is used to decide if food withholding is necessary to decrease the likelihood of deformities. This record is filed by species and ID.

### D Parent-reared Chick: Daily Log

Many chicks are reared by their own or foster parents. This record provides a running list of medical treatments and behavioral observations for a parent-reared chick. Column headings indicate: date, time of visit, if a bird was examined and medicated or treated, if a fecal sample was collected, body weight (not mass, see Chardine 1986), and general comments. This form is filed by species and chick ID.

### E Pair History: Behavior

For some pairs, especially those of endangered species, detailed behavioral notes are made throughout the breeding season. As a minimum, a running log should be kept indicating the degree to which a pair behaves as a social unit. Included are annual notes on the general frequency of unison calling (Archibald 1976), the distance routinely maintained between birds, the presence or absence of key social and agonistic displays (Masatomi and Kitagawa 1975) that indicate compatibility of mates, and peculiarities useful in signalling change in compatibility.

This form should include details of pair formation. For example, the record should indicate if the birds were removed from a flock as they naturally formed into a pair, or if the pair resulted from penning a male and female side by side until favorable behavior was observed. Details of pen numbers and duration of stay should be indicated here. This form is filed by species and male ID. Pair histories of extant pairs are filed separately from records of former pairs.

### F Pair History: Incubation

This form provides a year by year evaluation of incubation performance for the duration of the pair's existence. Column headings identify year, duration of incubation intervals, comments on incubation performance, and a performance score. Filing is by species and male ID.

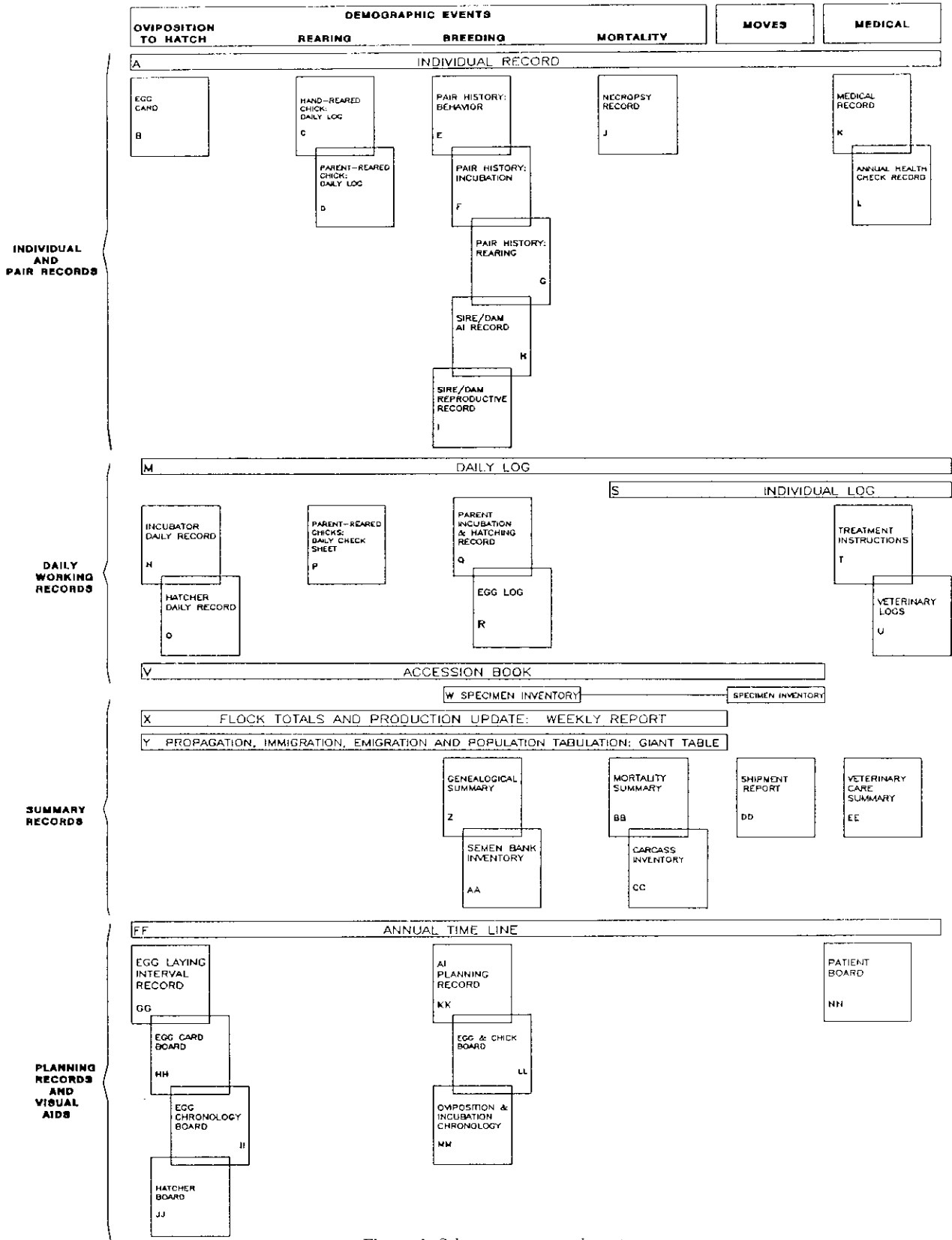


Figure 1. Schematic of records system.

INDIVIDUAL RECORD

ID 02-71001  
 Name MAS "C"  
 Species WC  
 Sex FEMALE  
 Method SEED Date 5/75  
 Sire ID WILD  
 Dam ID WILD  
 Other IDs \_\_\_\_\_  
 ORIGIN WBNP (ALEW-2)

HATCH DATE 6-02-71 or DATE OF ACQUISITION 5-18-71  
 Incubation Method: \_\_\_\_\_  
 Age on acquisition Egg

Artificial Incubators: Type: \_\_\_\_\_ No: \_\_\_\_\_ Dates: \_\_\_\_\_  
SUITCASE \_\_\_\_\_ 5/17-5/18  
PATERNAE B 5/19-5/22  
 Foster Parent Incub: ID \_\_\_\_\_ Dates: \_\_\_\_\_

Loan Reference: Owner \_\_\_\_\_ Since \_\_\_\_\_ Owner's ID \_\_\_\_\_

REARING METHOD: Type \_\_\_\_\_ Age of Chick \_\_\_\_\_ Foster Parents \_\_\_\_\_  
HAND 0-90 (Species and ID)

FLEDGE DATE (70 Days) 8-9-71  
 FLIGHT RESTRAINT METHODS Type \_\_\_\_\_ Date \_\_\_\_\_  
TENOTOMY 8-15-71

POST FLEDGING LOCATION and MATE

Pen No.	Dates	Pen No.	Dates and Mate ID
<u>B1P1</u>	<u>9-10-71</u>		
<u>B1/2</u>	<u>10-18-76</u>	<u>B1/2</u>	<u>10-18-76</u> <u>02-64001</u>
<u>B17/1A</u>	<u>11-10-85</u>	<u>B17/1A</u>	<u>11-10-85</u> <u>02-64001</u>

REPRODUCTIVE HISTORY IF FEMALE

Year	Eggs				Fertility (F/F+I) No. (%)	Hatched No. (%)	No. fledged (> 70 days) No. (%)
	Total laid	No. fert.	No. infert.	No. unkn.			
<u>1980</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1/2 50.0%</u>	<u>1 100%</u>	<u>0 0%</u>
<u>1981</u>	<u>4</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2/4 50.0%</u>	<u>1 50%</u>	<u>1 100%</u>
<u>1982</u>	<u>6</u>	<u>4</u>	<u>1</u>	<u>1</u>	<u>4/6 80.0%</u>	<u>2 50%</u>	<u>1 50%</u>
<u>1983</u>	<u>6</u>	<u>5</u>	<u>0</u>	<u>1</u>	<u>5/6 100.0%</u>	<u>5 60%</u>	<u>1 25.3%</u>
<u>1984</u>	<u>5</u>	<u>5</u>	<u>0</u>	<u>0</u>	<u>5/5 100.0%</u>	<u>4 80%</u>	<u>3 75.0%</u>

SPECIES: WC DAM ID: 02-71001 YEAR: 1987  
 DATE LAID: 4-20 PEN: B17 EGG NO.: 3  
 HATCHING DATE: PROJECTED 5-20 ACTUAL 5-21  
 FERTILITY: (YES) NO UNK DATE EXAMINED: 5-11  
 EMBRYO CONDITION: ED LD (H) METHOD: FLOATATION  
 CHICK ID \_\_\_\_\_

EGG TRANSFER:

MOVE NO.	DATE	FROM PEN TO PEN (comments)
<u>1.</u>	<u>4-20</u>	<u>B17 to R37</u>
<u>2.</u>	<u>5-20</u>	<u>pipped</u>
<u>3.</u>	<u>5-21</u>	<u>Hatched</u>
<u>4.</u>		

Figure 3. Egg card.

G Pair History: Rearing

This form provides a cumulative summary of a pair's performance in rearing chicks. Column headings indicate year, success or failure, failure class (chick killed by parents, chick died from neglect, pair exonerated, and chick death due to unknown causes), ages of chick during stay in pen, chick ID, an evaluation of chick weight gain early and late, and a performance rating for the pair during each year. Filing is by species and male ID.

H Sire/Dam Artificial Insemination Record

A detailed record is made on each bird involved in our artificial insemination (AI) program. These forms are used to evaluate responses to AI and to provide the raw data for investigating topics such as timing of semen production, synchrony of mates, and suitability of AI techniques. Headings and a few lines of data for these records appear in Figure 4A, B. Gee (1983) treats in detail crane responses to AI, and seasonal changes in pubic bones and cloaca, indicators of the approach of egg laying. The column for semen quality is based on concentration and motility of spermatozoa upon microscopic examination of a capillary tube sub-sample. Sire/Dam AI Records are filed by year, species, and pen or ID. The original copies of this form, arranged by pen number, are included in a looseleaf notebook that serves as an annual field log for AI.

I Sire/Dam Reproductive Record

The Sire/Dam Reproductive Records (Figures 5A, B) provide a cumulative list, egg by egg, of the reproductive performance of each breeding adult. Not only can fertility and hatchability be evaluated by this form, but any aberrancy in chick survival is also apparent. These forms are prepared at the end of the breeding season from Egg Cards, the Egg Log, and the Sire/Dam AI Records. Filing is by species and ID.

INDIVIDUAL RECORD (CONTINUED)

SEMEN PRODUCTION SUMMARY IF AI MALES

Year	Semen						
	No. attempted collections	No. samples collected	No. good samples	Date of first sample	Date of last sample	No. of days semen produced	Average volume
_____	_____	_____	_____	_____	_____	_____	_____

ID OF PROGENY: \_\_\_\_\_

REPRODUCTIVE HISTORY IF NATURALLY BREEDING MALES

Year	Mate ID	Eggs				Fertility (F/F+I) Ratio (%)	Hatched (%)	No. fledged (> 70 days) Ratio (%)
		Total Laid	No. Fertile	No. Infertile	No. Unknown			
_____	_____	_____	_____	_____	_____	_____	_____	_____

MAJOR MEDICAL PROBLEMS: Date \_\_\_\_\_ Type \_\_\_\_\_

PHYSICAL ABNORMALITIES TENOTOMIZED LEFT WING

BEHAVIORAL CHARACTERISTICS  
NOT AGGRESSIVE, THUMBS ON WING DURING AI  
FAIR INCUBATOR, GOOD AT PARENTING

REMOVAL  
 Transfer: Type \_\_\_\_\_ Date \_\_\_\_\_ Destination \_\_\_\_\_ New ID \_\_\_\_\_

Death: Date \_\_\_\_\_ Cause \_\_\_\_\_ Place \_\_\_\_\_  
 Deposition of Carcass \_\_\_\_\_

Figure 2. Individual record.

SIRE ARTIFICIAL INSEMINATION RECORD										Year	Species	ID
										1986	MSHC	03-72001
Date	Time	Weather	Response	Vol.	Quality		Female	Vol	Spec.	Remarks		
					Conc.	[Motil.]	Insem.	Insem.	Frozen			
3.26	0930	45° SUN	3	.005	2	1	-					
3.31	0940	47° SUN	3	.005	2	2	-			DEFICATED DURING AI		
4.4	0925	45° (CLOUD)	3	.01	3-	3-	MATE	.01				
4.7	0920	50° SUN	2-	NS			MATE					
4.9	0845	55° SUN	3	.02	3+	3+	MATE	.02				
4.11	0910	48° (CLOUD)	3-	.005	3+	3+	MATE	.005				
4.14	0930	45° (RAIN)	3	.035	4-	4-	MATE	.035		CONTAMINATED SAMPLE		
4.16	0945	55° (CLOUD)	3+	.045	4-	4	MATE	.025	✓(.02)			
4.16	0930	57° SUN	3+	.03	3	4	MATE	.03				
4.21	0925	65° SUN	4-	.04	3	4-	MATE	.02	✓(.02)			
4.23	0940	65° SUN	2+	NS								
4.25	0920	60° SUN	2+	.04	4	4	MATE	.04				
4.28	0915	55° (CLOUD)	3+	.04	4	4	MATE	.04				

Figure 4A. Sire artificial insemination record.

DAM ARTIFICIAL INSEMINATION RECORD													Year	Species	ID
													1986	SCOTTISH FLEAT	02-48003
Date	Time	Weather	Response	Pubic bones	Cloaca condit.	Male donor	Vol. insem.	Quality		Insem. site	Egg No.	Egg date	Fert.	Remarks	
								Conc.	[Motil.]						
1.20	0935	45° SUN	2+	1.5	2.1	WEP	24	3	1	0					
2.12	0915	35° SUN	2+	1.4	1.8	WEP	10	2	2	0					
3.25	0910	40° (CLOUD)	2	1.9	1.9	WEP	11	3	2	0					
2.21	0945	37° (RAIN)	2	1.8	1.5	WEP	13	3	2	0					
4.11	0950	47° (RAIN)	3+	1.7	1.4	WEP	13	3	2	0					
3.4	0920	45° (CLOUD)	3	1.7	1.7	WEP	15	3	2	0					
4.4	0910	48° (CLOUD)	3	1.8	1.8	WEP	10	2	2	0					
3.8	0925	48° (CLOUD)	3	1.8	1.5	WEP	10	2+	2	0					
2.11	0915	35° SUN	2+	1.8	1.8	WEP	16	3	2	0					
4.13	0915	45° SUN	NW											REMOVING BLOOD	
2.15	11.00	50° SUN	NW											EXTENSIVE	
4.15	0900	57° (CLOUD)	AIW												
2.20	0940	45° (RAIN)	3	1.5	2.0	WEP	13	3	2	0					
2.22	0955	47° SUN	2+	1.8	1.8	WEP	10	2+	2+	0					
3.25	0915	35° SUN	2+	1.9	1.8	WEP	14	3	2	0					
3.27	0915	40° (RAIN)	2+	1.9	1.7	MATE	15	3	2	0					
2.21	0950	42° (CLOUD)	3+	2.0	2.0	WEP	14	3+	2+	0					
4.1	0940	50° SUN	2+	2.0	2.2	WEP	12	3	2	0					
4.2	0940	55° SUN	2	2.0	2.2	WEP	12	3	2	0					
4.5	0900	50° SUN	2+	2.0	2.2	WEP	12	3	2	0					
4.6	0915	60° SUN	2	2.0	2.2	MATE	10	3	2	0					
4.8	0930	69° SUN	3	2.0	2.2	MATE	15	3	2	0		4/8	TH		
4.11	0915	60° SUN	3								2	4/11	TH		
4.12	0950	65° SUN	3-	1.8	1.6	MATE	15	3+	3	0					

Figure 4B. Dam artificial insemination record

SIRE REPRODUCTIVE RECORD<sup>1</sup> ID 02-69002  
Species WC  
Name PAX

Egg Date	Dam ID	Egg No.	Clutch No.	Fertil. Method (AI, Nat.)	Egg Fate		Progeny				
					Fertility (F, I, U) No. (%)	Hatch (+, -) No. (%)	Hatch Wt.	ID	Sex	Age at Death	Fledge <sup>2</sup> (+, -)
4-8	02-69003	1	1	AI	F	+	120g	02-86009	M	4 days	-
4-11	02-69003	2	1	AI	F	+	119g	02-86021	M		+
4-22	02-69003	3	2	AI	I	-					
4-25	02-69003	4	2	AI	F	+	121g	02-86030	F		+
5-9	02-69003	5	3	AI	F	+	115g	02-86043	F		+
1986		5	3		4/5 (80)	4/4 (100)				2.2	

<sup>1</sup> Only those eggs included that are certainly or most likely sired by this male.  
<sup>2</sup> Fledging date equals 70 days of age.

Figure 5A. Sire reproductive record.

DAM REPRODUCTIVE RECORD ID 02-69003  
Species WC  
Name KLEWI

Egg Date	Egg No.	Clutch No.	Fertility Method (AI, Nat.)	Incubation Method	Sire ID		Mo-Day Hatched	Progeny				
					Degree of Certainty Positive	Most Likely		Hatch Wt.	ID	Sex	Chick Fate Age at Death   Fledge <sup>1</sup> (+, -)	
4-8-86	1	1	AI	NATURAL	02-69002		5-8-86	120g	02-86009	M	4 days	-
4-11-86	2	1	AI	NATURAL	02-69002		5-10-86	119g	02-86021	M		+
4-22-86	3	2	AI	NATURAL		02-69002	INFERTILE					
4-25-86	4	2	AI	NATURAL		02-69002	5-24-86	121g	02-86030	F		+
5-9-86	5	3	AI	NATURAL	02-69002		6-9-86	115g	02-86043	F		+
1986	5	3									2.2	
4-2-87	1	1	AI	NATURAL	02-69002		5-2-87	116g	02-87011	F		+
4-5-87	2	1	AI	NATURAL	02-69002						0.1	EARLY DEAD EMBRYO
1987	2	1										

<sup>1</sup> Fledging date equals 70 days of age.

Figure 5B. Dam reproductive record.



## J Necropsy Record

On this form, details of the post-mortem examination and the results of histopathological tests are recorded. Included is information on location and time of death, weight, general body condition, and relevant facts about medical history as well as anatomical abnormalities. The form lists tissues and other materials retained, carcass deposition, and information on diagnosis and, where possible, cause of death. We recommend the tabular separation of the most frequent causes of death for ease in data extraction. This form is filed by species and ID and may be attached to the Individual Record and/or filed with other medical records.

## K Medical Record

For chicks, the Hand-reared or Parent-reared Chick: Daily Log serves as a medical record. For a fledged bird, a separate Medical Record is created when the bird first shows clinical signs requiring veterinarian care. Medical Records include a summary of treatments and personnel involved in patient care as well as a description of the injury or disease. Other categories on the form are pen numbers, physical condition (by body area), laboratories involved in pathogen cultures, bacteriological, viral, and hematological findings, and results of fecal examinations. Filing is by species and ID; live bird records are filed separately from dead. The Medical Record for dead birds may be filed with the Individual Record and Necropsy Record.

## L Annual Health Check Record

In the fall of each year, each bird is given a physical examination. Categories on this form provide general reference information (ID, date), a checklist of body areas physically examined, a list of samples taken (for example, blood or feces), treatments given (for example, antihelminthic agents, trimming of nails or bill), and comments. The results of tests are also catalogued on the form. This record is filed by species and ID for living birds and, like other medical records, may be filed with the Individual Record after the death of the bird.

## DAILY WORKING RECORDS

### M Daily Log

Animal caretakers make a preliminary record of husbandry activities in the Daily Log. Thereafter, many details (such as pen to pen moves, unusual behavioral observations, and injuries or illnesses) are transferred to the Individual Log or specific record sheets, but the Daily Log from each year is retained and filed chronologically. This is the only record of many routine activities.

### N,O Incubator Daily Record and Hatcher Daily Record

These forms provide a log of mechanical incubator and hatcher temperature and humidity conditions. Column headings include date, time, wet bulb temperature, dry bulb temperature, comments, and initials of caretaker.

Typically, readings are taken four times per day. These reports are filed chronologically or according to machine number.

### P Parent-reared Chicks: Daily Check Sheet

This form (Figure 6) is taken into the field to record physical condition and medical treatments for all chicks for one day. Column headings indicate physical examinations, medical treatments, body mass, fecal collection and results, and comments. One row is for each parent-reared chick in the order visited. When complete, the information for each chick is then transferred to the appropriate Parent-reared Chick: Daily Log. These forms are filed chronologically with separate folders for each year. At the end of the breeding season, the information for each chick is transferred to the appropriate summary records.

### Q Parent Incubation and Hatching Record (Walk Through Sheet)

This check sheet is prepared daily for the caretaker to use while walking through the crane colony to inspect each pair, to determine if the pair has the number of eggs indicated on the form, and to evaluate nest attendance. Row headings on the form are pen numbers in the order they will be encountered while walking through the colony. Column heads provide for number and condition of eggs and activities of parents during early morning, midday, afternoon, and evening visits. One copy of the form is sufficient for 70 pairs. At the end of the day, information on egg numbers is transferred from that day's form to the form for the next day. This form is also used to plan egg moves and to rate each pair's incubation performance at the end of the breeding season.

### R Egg Log

One copy of this record provides a chronological list of all eggs laid for each species or subspecies. Column headings indicate lay date, foster incubators, egg fertility, method of fertility determination, projected hatch date, actual hatch date, type of rearing, foster parent IDs, and comments. Data from these forms are used for productivity summaries.

### S Individual Log

A running log of events pertaining to the individual is kept here. The information is later transferred to more specific records such as the Medical Record or Pair History: Behavior. Filing is by species and ID.

### T Treatment Instructions

The veterinarian provides detailed instructions to technicians concerning procedures, schedule, and medications. After the bird is discharged from medical care, this record is abstracted into the Medical Record and either discarded or filed with the Medical Record.

PARENT-REARED CHICKS: DAILY CHECK SHEET										Date <u>6-25-86</u>	
Pen	Chick Sp-ID	Age	Wt.	Phys. Exam	Medications/Treatments					Fecal	Comments
					Medic. Water	SQ Injections		Oral Tubing			
					Amprol 2cc gal	Gentocin 0.1cc 100g	Ivomec 0.1cc 100g	Other	Panacur .1cc 100g		
R43	04-86060	4	123g	✓	✓						OK
R37	07-86058	5			✓						OK
R33	03-86058	35			✓						OK
R23	05-86030	25			✓						OK
R21	05-86058	5			✓						OK
R4	05-86050	8			✓						OK
R15	03-86018	26			✓						OK
R6	03-86021	25	1175g	✓	✓				✓	✓	ALITTLE RASPY
RB	05-86045	11			✓						OK
R13	02-86075	24			✓						OK
G19	03-86063	3	120g	✓	✓	✓					3cc FLUIDS
I+R	05-86047	11			✓						OK
O7	02-86040	17			✓						OK
S+R	05-86012	28			✓						CHECKED EYE OK
Y9	04-86031	23			✓						OK
Y25	05-86029	25	1510g	✓	✓				✓	✓	OK
Y11	05-86025	19			✓						OK
Y13	05-86013	28			✓						OK
Y15	04-86051	7			✓						OK
Y45	05-86027	24			✓						OK
Y43	04-86028	24			✓						OK
Y41	03-86004	1	110g	✓	✓	✓					2cc FLUIDS, ✓WING
Y37	05-86019	26			✓						OK
05	04-86068	0	127g	✓	✓	✓					BITADINE UMBILICUS OK

Figure 6. Parent-reared chicks: Daily check sheet.

#### U Veterinary Logs

Three log books provide a chronological record of veterinary activities: (1) the Necropsy Log documents observations, samples, cultures, other materials, fate of carcass, and diagnosis; (2) the Radiology Log indexes the radiograph files; and (3) a Laboratory Log reports detailed results of microbial cultures, fecal examinations, blood tests, etc. All three logs are indexed by bird ID and are retrievable by reference numbers on the Medical Record or Necropsy Record.

#### V Accession Book

The Accession Book is one of the most fundamental records kept for an animal colony. Akin to the specimen catalog for a museum, it is a cumulative log of all cranes

that have been or are a part of the colony. Various species can be logged in different books or, more commonly, all are logged in the same book chronologically according to arrival date of the individual or according to hatching or fledging date (for chicks originating at the facility). All birds that reach fledging are included, but chicks that die before fledging may or may not be included. Birds are also included that are owned by the institution but housed elsewhere.

Column headings are ID, name, former or extraneous markings or tags, sex, hatch date and place, dam and sire (ID and names), ownership, method and date of acquisition, departure information (date, destination, and purpose), and death date, location, and cause.

Because of the value of this record, we recommend keeping duplicate copies (updated annually or more frequently) at a separate location.

## SUMMARY RECORDS

### W Specimen Inventory (Monthly Report)

For each species, a Monthly Report is prepared. Individual birds are listed in reverse chronological order except that paired females are listed immediately after their mates. Column headings indicate ID, origin, rearing method, sex, wing condition, and pen number. One column is left open for comments on peculiarities of the crane. A duplicate copy of this report is carried by animal caretakers when returning birds to pens and in locating individuals in the colony. A copy of each monthly update is placed chronologically in the archives to act as a historical description of the colony for each month of its existence.

### X Flock Totals and Production Update (Weekly Report)

A weekly summary of flock size is prepared by balancing natality and acquisitions with mortality and birds leaving the colony. Row headings are the taxa represented in the colony. Column headings indicate the number of adults, pairs, eggs produced (this week and this season), young produced (for week and season) and mortality for adults and young (this week and for the year). This report provides a summary for internal review and for informing cooperators of recent changes in captive colonies. The Weekly Report is our most useful document for reviewing egg production and chick survival during the breeding season. Reports are filed chronologically.

### Y Propagation, Immigration, Emigration and Population Tabulation (Giant Table)

The demography of each species within the colony is summarized for its entire history in the Giant Table. Row headings are years. In our version, 56 columns are divided into 7 major column groups as follows:

- A. Productivity
  1. from artificial insemination
  2. from naturally breeding pairs
  3. from unpaired females
- B. Eggs arriving from outside the colony
- C. Birds arriving from outside the colony
- D. Eggs and birds sent from the colony
- E. Summary of productivity through AI and natural breeding
- F. Mortality
- G. Year end flock size (by age class)

Within each major group, appropriate divisions are made for the number of productive males and females and number of eggs that are potentially fertile, fertile, infertile, and of unknown fertility. Fertility, hatchability, and fledging ratios and percentages are also given. This table, as updated at the end of each breeding season, is our most useful document for quickly summarizing demographic trends for each species within the colony.

### Z Genealogical Summary

The genealogical records for each crane taxon are derived from Sire/Dam Reproductive Records and AI Records. An ancestral chart, similar to that used for humans and available from state genealogical societies, is useful as a visual aid. Genealogical records, kept for all known captive individuals of a species (for example, Sheppard 1985), are similar to Accession Books but frequently include in-breeding coefficients.

### AA Semen Bank Inventory

This inventory system consists of a running log of samples entering the semen bank, and a semen inventory file wherein all samples from an individual male are listed as they enter the bank. Detailed records on the handling of each sample (Gee 1983, this proceedings) are also made, but the essential details of semen quality, volume, location, and source are recorded on the inventory sheet for each donor.

### BB Mortality Summary

Crane mortality is tabulated by species from the Necropsy Records and the Necropsy Log. At the beginning of each year, a new record is begun. Column headings provide date, identity and age of the individual, and diagnosis. Filing is by year and taxon.

### CC Carcass Inventory

A running list is kept of each carcass of each species. In addition, a tag including death date, ID, and cause of death is attached to each carcass. The Carcass Inventory includes data from the specimen tag plus storage site, final deposition site, and necropsy number. This report is kept in the permanent files. For ease in data entry, however, a copy can kept at the carcass storage site.

### DD Shipment Report

This is a running list of the birds sent to or received from other institutions. Column headings indicate date sent, species, ID number, method of transport, recipient, and purpose of transfer.

### EE Veterinary Care Summary

From the records listed in the "medical" and "mortality" columns in Figure 1, a Veterinary Care Summary is prepared annually. Included are totals by sex and age class for surgical, diagnostic, and radiographic procedures, and for medications used. An overview of significant morbidity and mortality factors for the year is provided, as well as trend information and recommendations for colony management.

## PLANNING RECORDS AND VISUAL AIDS

### FF Annual Time Line

This display board is a valuable aid in planning activities that occur for only a portion of the calendar year. Column headings are the months of the year. Row headings are schedulable activities such as vegetation control, annual bird moves, the onset and termination of artificial light, banding, bird shipments, changes from breeder to maintainer ration, health checks, tenotomies, AI, egg laying, parent rearing, and brailing. By color coding bar graphs, it is possible to display scheduled events for several species on one time line.

### GG Egg Laying Interval Record

The duration and timing of the egg laying period for each year and the intervals between eggs are summarized for each female in this report (Figure 7). The timing of egg removal, important in assessing maximum productivity, should be indicated for each egg on the form. Either eggs are removed sequentially (within a few hours of laying) or as complete clutches (within a few days after the clutch is complete) (Derrickson and Carpenter 1981). This form is filed by species and year.

### HH Egg Card Board

On this display board, each pen containing a pair of cranes is given a label. As eggs are laid, introduced, or removed, the Egg Cards are affixed beneath the appropriate pen labels on the Egg Card Board. This board provides a quick update on the location of each egg in the breeding colony and, together with the Egg and Chick Board, is one of our most useful visual aids in planning egg moves and many other aspects of foster parent incubation.

### II Egg Chronology Board

This aid is used to follow the progress of a selection of the most valuable eggs (usually the eggs of endangered species). Column headings indicate dates; rows indicate individual eggs. Each egg is represented by a 30 day long adhesive strip affixed to the board when an Egg Card is created. General events in the incubation of all eggs (for example, timing of earliest vocalizations, entry into the air cell, and pipping) are printed on each strip. Egg locations are written on the strip following each egg move. Using the Egg Chronology Board, a caretaker can quickly determine location and stage in development for each egg.

### JJ Hatcher Board

When late term eggs are moved from artificial incubators or foster parents to the hatcher, the Egg Cards are moved to this display board.

### KK Artificial Insemination Planning Record

A detailed breeding strategy for each individual in the colony is condensed into this form. Copies are included for

easy reference in the annual field log for AI (see H). This record provides a useful brief description of the pair history and AI recommendations. Column headings indicate pen or ID, rearing type of each adult, wing condition, year of first breeding, prior AI outcome, AI recommendations and justification, team members, and semen donor priority. Filing is by species and year.

### LL Egg and Chick Board

This magnetic board displays the number and species of eggs or chicks each pair is incubating or rearing. As for the Egg Card Board, each breeding pair in the colony is here listed according to pen number. Beneath each label, colored circles and squares indicate the appropriate number and species for eggs and chicks for each pair. This visual aid is especially useful in planning egg and chick care during the period when many pairs of foster parents are in transition from incubation to chick rearing. In contrast, the Oviposition and Incubation Chronology, treated next, and the Egg Card Board are most useful during incubation. Later, the Parent-reared Chicks: Daily Check Sheet is most useful during chick rearing.

### MM Oviposition and Incubation Chronology (Check Sheet)

This large display form depicts the chronology of egg laying and egg moves for a breeding season. Column headings indicate days beginning with the date of the first egg of the season. Rows indicate either dam ID or pen numbers. All females of one species are grouped together with the first female to lay occupying the most elevated row. A check mark indicates that the pair is incubating. A check mark underlined indicates the day oviposition occurred. Eggs removed or added are indicated by plus or minus numbers. For example, a two-egg clutch removed to encourage a pair to lay again would be indicated by a "2" in lieu of the check for that day. This form simplifies predicting when a pair is due to recycle (relay). The form is also useful in planning egg moves and in recycling pairs so that the best foster parents are in the proper reproductive state to receive eggs or chicks of endangered species. One form is generated each year. Filing is chronological.

### NN Patient Board

This display board is maintained at the hospital with an abbreviated version placed in the most frequently visited work area. Both display boards serve as visual aids for use in caring for hospitalized cranes. The board at the hospital is a convenient place for posting treatment instructions and other records pertinent to patient care.

## SYSTEM USE

The 40 or more forms that comprise the system provide a broad framework for the management of the most important data for a crane colony. Not all records need to be employed to use the system. For example, if at one institution all eggs are mechanically incubated and all chicks are

hand-reared, then those records dealing with foster parent incubation (F, Q, R, GG, HH, LL, and MM) and foster parent rearing (D, G, P, and LL) need not be used. If in one colony, all propagation is through naturally fertile pairs, then all records dealing with artificial insemination (H, AA, KK) can be eliminated.

The system can also be streamlined for use in very small crane colonies. Where few breeding pairs produce few eggs, many of the visual aids and production records become unnecessary.

The core of the records system, however, provides an organizational framework for the retention of data essential to the long term management of a crane colony. The

most fundamental records are those dealing with general demography and health (A, H, I, V, W, Z, and Y). Little can be omitted from this nucleus of records without sacrificing the future usefulness of the colony.

Filing instructions are mentioned in the discussion for each record. Some records are considered so valuable that we recommend that a duplicate copy be stored in a separate building.

Without actually using the system for an extended period, it is difficult to understand the flow of information through the system. Table 1, however, provides an overview of system use. Here, appropriate system responses are portrayed for many life history events. When an egg

Egg Laying Interval Record															
Species <u>Whooping Crane</u>															
ID	Year	Total Eggs	Season Length	Last Egg	Egg #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11										
					#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
02-71001	1978	16	83 days	30 MAY	8 MAR.	4	6	16	4	6	4	5	4	6	3 (Cont'd)
	1979	14	79 days	1 JUNE	14 MAR.	3	18	3	9	5	5	5	6	5	"
	1980	14	77 days	7 JUNE	22 MAR.	5	6	7	3	9	3	9	5	3	8
	1981	16	91 days	16 JUNE	3 MAR.	3	11	8	3	10	3	8	5	4	8
02-68003	1984	4	21 days	23 MAY	5 MAY	9	6	6							

Figure 7. Egg laying interval record.

hatches, for example, first the Egg Card (B) is removed from the Hatcher Board (JJ) and the hatching date is placed on the Egg Card (B), the Dam Reproductive Record (I), and the Oviposition and Incubation Chronology (MM). A change is made on the chalk board, precursor of the Weekly Report (X), and on the Egg Chronology Board (II). Finally, an entry is made in the Accession Book (R) and an Individual Record (A) is created. Ultimately, the Specimen Inventory (W), Giant Table (Y), and the Genealogical Summary (Z) must also be modified. All of these changes must be made by hand in a manual system. In a computer managed relational database, however, entry of the hatching event at one level will yield appropriate system responses for all

other records linked in the software matrix.

#### CONCLUSION

The system described above consists of a complex array of records linked through limited redundancy to provide for the systematic retention and collation of the data of general interest in managing a large crane colony. The system can also be pared down for use in smaller colonies or can be modified for use with other taxa. The use of such a system is essential to the long term management of any crane colony intended for propagation or scientific research.

	Oviposition	Hatching	Pairing	Pen Move	Sickness Before Fledging	Sickness After Fledging	Death Before Fledging	Death After Fledging
A Individual Record		+	+	+		+	+	+
B Egg Card	2	+						
D Parent-reared Chick: Daily Log		+			+		3	
H Sire/Dam AI Record	+	+						
I Sire/Dam Reproductive Record	+	+						
J Necropsy Record							+	+
K Medical Record						+		+
M Daily Log				1		1		1
P Parent-reared Chicks: Daily Check Sheet		+			1		2	
Q Parent Incubation and Hatching Record	1	1					1	
R Egg Log	+	+						
S Individual Log			+	+		+		+
T Treatment Instructions						+		
U Veterinary Logs						+		+
V Accession Book		+					+	+
X Flock Totals and Production Update	+	+					+	+
CC Carcass Inventory								+
II Egg Chronology Board	+	+						
LL Egg and Chick Board	+	+					+	
MM Oviposition and Incubation Chronology	+	+						
NN Patient Board						+		

Table 1. Immediate records system responses to some natural history events for a foster parent-reared crane.

#### ACKNOWLEDGMENTS

The record system presented here is based heavily on two decades of trial and error development at our home institutions. The following contributed most heavily to evolution of the system: at ICF, George Archibald, Chris LaRue, Claire Mirande, Mike Putnam, Shirley Russman, and Scott Swengel; and at PWRC, James W. Carpenter, Gene Cowan, Scott Derickson, Ray C. Erickson, George Gee, Cam Kepler, and John Stegeman. Contemporary craniacs Mark Albaugh, Dan Day, and Thom Lewis interacted closely with us in planning and testing the system. Cathy Ellis and Jill Clarke helped in manuscript preparation. All of these individuals have our appreciation as do those who commented on the manuscript.

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# FLIGHT RESTRAINT TECHNIQUES FOR CAPTIVE CRANES

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## ABSTRACT

Traditional techniques for preventing escape of captive cranes (i.e., tenotomy, tenectomy, wing clipping, confinement under nets, and amputation) are discussed briefly. Two additional techniques (i.e., brailing and vane trimming) are described in detail. The advantages and limitations of each technique are presented.

## INTRODUCTION

Many methods have been used to prevent escape of captive birds, including: (1) amputation (removal of all or a portion of the wing) (Young 1948; Schwarte 1965; Sedgewick 1967; Williamson and Russell 1971; Robinson and Buzikowski 1975; Osinskii and Taran 1978; Madill 1981; Wallach and Boever 1983; Amand 1986); (2) tenotomy (severing the extensors of the hand) (Schroeder and Koch 1940; Miller 1973); (3) tenectomy (removal of a portion of the extensors of the hand) (Schwarte 1965; Sedgewick 1967; Miller 1973; Amand 1986); (4) patagiectomy (removal of the patagial membrane and apposition of the radius and humerus) (Sedgewick 1967; Mangili 1971; Robinson 1975; Madill 1981); (5) functional ankylosis (fixing the ulna, carpal and metacarpal bones with stainless steel wire) (Sedgewick 1967); (6) wing (feather) clipping (cutting the distal portions of the primary and secondary feathers) (Young 1948; Schwarte 1965; Sedgewick 1967; Gandall and Amand 1982; Amand 1986; Harrison and Harrison 1986); (7) brailing (binding one wing) (Schwarte 1965; Zwank and Derrickson 1981; Amand 1986); and (8) confinement under nets. Radical amputation of the wing would also render birds flightless but is little used because captive birds are usually confined for propagation or display purposes, uses which presumably would be impaired by extensive mutilation.

In the following, we provide details of the methods in use to restrain approximately 300 cranes (about 40 whooping cranes *Grus americana* and 260 sandhill cranes *G. canadensis*) presently maintained at the Patuxent Wildlife Research Center (Center). Included is one method, brailing, used historically by falconers (Michell 1959), which has been adapted for our use with cranes, and a recently developed technique, vane trimming, which renders young cranes flightless from fledging age until they can be safely wing clipped (when their quills are fully grown).

## METHODS IN USE AT THE PATUXENT WILDLIFE RESEARCH CENTER

We employ the following methods: (1) overhead nets, (2) tenotomy, (3) wing (feather) clipping, (4) vane trimming, and (5) brailing. Amputation, tenectomy, and patagiectomy are not in use at the center because less radical measures appear fully suitable in rendering birds flightless.

### Netted Pens

Nets are used for birds that are intended for release or are intended to become full-winged captive breeders. We recommend nylon covered chain link pens for confining full-winged birds. At the Center we have 23 net covered pens varying in size from two small quarantine pens (30 x 50 ft; 9.1 x 15.2 m) to flight pens used for conditioning birds for release (100 x 30-50 ft; 30.5 x 9.1 - 15.2 m) and breeding pens (65 x 45 to 100 x 50 ft; 19.8 x 13.7 to 30.5 x 15.2 m). Vertical fences are typically 8-ft (2.4 m) tall. Nets are supported by 3/8-in (1 cm) plastic-coated steel cables crossing the pens at 20-ft (6.1 m) intervals.

We use 2-in (5.1 cm) mesh nylon nets and recommend this mesh size as a maximum. At the International Crane Foundation, birds held under nets with larger mesh are occasionally snared by the net and held suspended when one or both wrists pass through the mesh (G. Archibald and S. Swengel pers. comm.). Occasionally, when a bird springs up against the nets at the Center, it passes its head through the mesh and is momentarily held suspended. Sandhill cranes pull free under their own weight as do most whooping cranes. Rarely, however, a whooping crane is held suspended until pulled free by a caretaker. We have incurred no known injuries from these incidents, but we believe that this problem could be avoided by using a smaller mesh for whooping and other large cranes.

Netted pens offer the advantage of allowing birds to be full-winged and therefore presumably better able to

balance during copulation. Chances of reproducing naturally (without artificial insemination) are thereby increased. By 1990, five pairs of Mississippi sandhill cranes *Grus. c. pulla* housed under nets produced fertile eggs. We also maintain seven pairs of full-winged whooping cranes but only one pair has proven to be naturally fertile.

In cooler environments where snow or ice storms are likely, netted pens may collapse unless heavily braced. In February 1987, 15 of 23 netted pens at the Center collapsed under heavy snow. If a sufficiently large work force and sufficient temporary vertical support posts are available, it is possible to maintain netted pens during snow or ice storms.

### Tenotomy

Tenotomy is used to permanently eliminate flight capability. This process involves using a thermo-cautery instrument (Figure 1A) to sever the *tendo longa* (terms after Baumel 1979) of the *musculus tensor propatagialis* and the tendonous attachment of the *musculus extensor metacarpi radialis*. The destruction of the synovial capsule of the wrist (*junctura carpi*) results in permanent ankylosis. The operation should be performed with a local anesthetic. We infiltrate the site with 2-3 ml of 2% lidocaine HCl, wait 5 minutes before surgery, and freeze the skin surface with an ethyl chloride spray immediately before surgery. Young birds are typically tenotomized in the fall of their first year. In the weeks prior to the tenotomy, young birds are held flightless using one of the other methods. After tenotomy, the wing is taped tightly folded for six weeks to promote ankylosis.

About 5% of our tenotomized cranes are, in a strong wind, sufficiently capable of flight that they can vault an 8 ft (2.4 m) fence. To prevent escape of such birds we clip the primaries of the tenotomized wing at yearly intervals. The result of a successful tenotomy is a cosmetically pleasing bird (Figure 1B) that is sufficiently imbalanced because of the asymmetry of its wing surfaces to be unable to rise higher than 1-2 m even in a strong wind.

At the Center, we are currently investigating the role of wing condition on crane fertility. Although the study is still underway, about 50% of the tenotomized male Florida sandhill cranes *G. c. pratensis* in our captive colony were able successfully to fertilize eggs.

### Wing Clipping

Wing clipping is used for birds that are to be held flightless for at least 3 years, but may be intended for flight thereafter. To wing clip a crane, the primaries and three or more of the distal secondaries from one wing are cut with scissors (Figure 1C). Typically, each rachis is cut about 1 inch (2.5 cm) from its point of emergence from the integument. Cranes living in windy areas (where they can achieve greater lift with the clipped wing), birds in pens with shorter fences, and those with exceptional escape capabilities are wing clipped even more extensively than illustrated.

Cranes at the New York Zoological Society facilities are clipped somewhat differently (S. Balzano, pers. comm.). The three most distal primaries are left intact, but all other primaries and approximately two-thirds of the secondaries are clipped. This variation reportedly allows male cranes to balance better during copulation.

When clipping, special care is taken to avoid cutting any feather that is still growing. Profuse and prolonged bleeding from the quill occurs if this precaution is not taken. To prevent cutting the rachis too soon, the wing is spread and the underside of the wing is inspected to identify blood quills. Feathers that are still growing are temporarily vane trimmed, as described below, and later clipped when hard-penned (fully grown and free of blood in the calamus).

### Vane Trimming

Vane trimming is used temporarily to ground birds while their flight feathers (primaries and secondaries) are still growing. Once the flight feathers are hard-penned, the rachis is clipped.

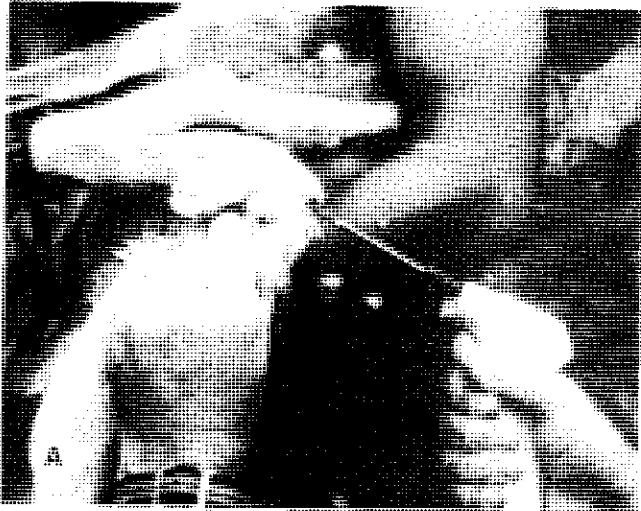
In this process (Figure 1D) a portion of the vanes of the primaries and the distal three to six secondaries of one wing are trimmed with scissors. The rachis and the feather tip is left untrimmed to prevent birds in social groups from striking pen mates with sharp rachis tips. As illustrated, the outer vane of the five most distal primaries is left intact to prevent breakage of the rachises. Once a feather is hard-penned, it is clipped as shown in Figure 1C. Those chicks that are later to be wing clipped or tenotomized are vane trimmed at 60 to 70 days of age depending on individual growth rates and local conditions.

### Brailing

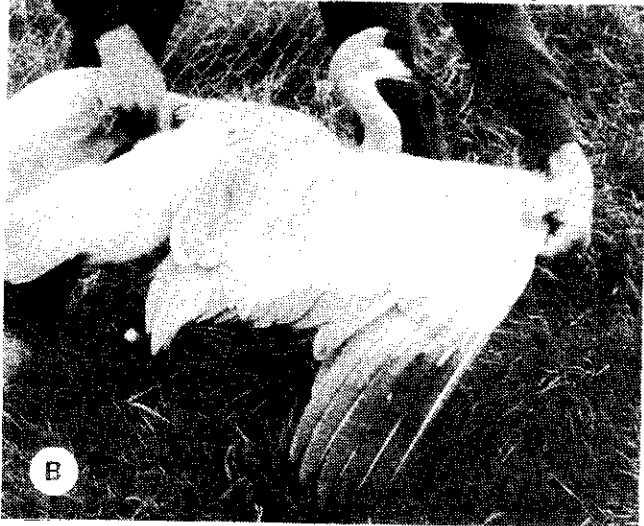
This technique is used for temporarily restraining fledglings (that are to be later placed in flight pens or released), flighted adults, and birds during shipment. At the Center we rear many chicks in open pens with tenotomized or wing-clipped foster parents. As chicks approach fledging, they are inspected to determine when flight restraint is necessary. Chicks that are to remain full-winged (flighted) are placed in netted pens or brailed at about 60 to 65 days of age. The age of first brailing varies a few days depending on individual development, propensity to fly, and wind conditions.

Shipped birds are sometimes brailed on each wing. For other purposes, birds are brailed on one wing for two weeks at most, then rebrailed on the opposite wing. Brails are changed at regular intervals to prevent ankylosis of the immobilized wing. Epperson (1982) found significant but reversible impairment in wing extension capability in birds brailed only two weeks. Typically, birds regained full flight capability within 1 to 2 weeks of removal of the brail.

The procedure requires a brail and a riveting device. For the brail, we use a narrow band of flexible plastic 3/4 x 15 in (2x37.8 cm) wide and approximately 1 mm thick. To secure the brail, we use a commercially available rivet gun. Leather straps and other riveting or sewing devices can be readily substituted as long as the following conditions for proper fit are met.



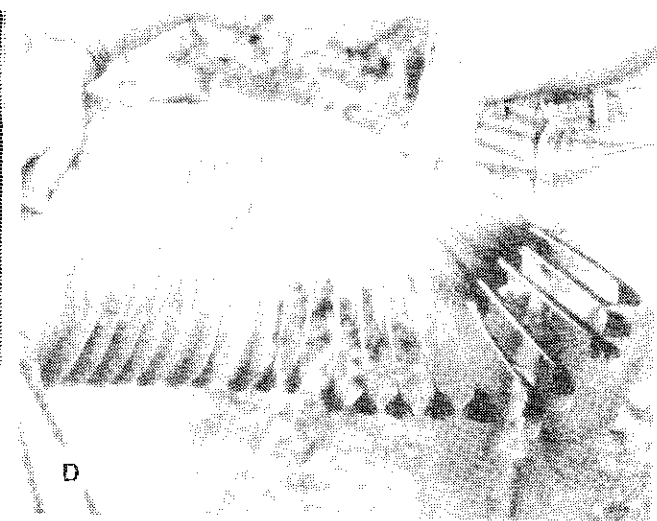
A. A tenotomy is performed on the folded wing with a



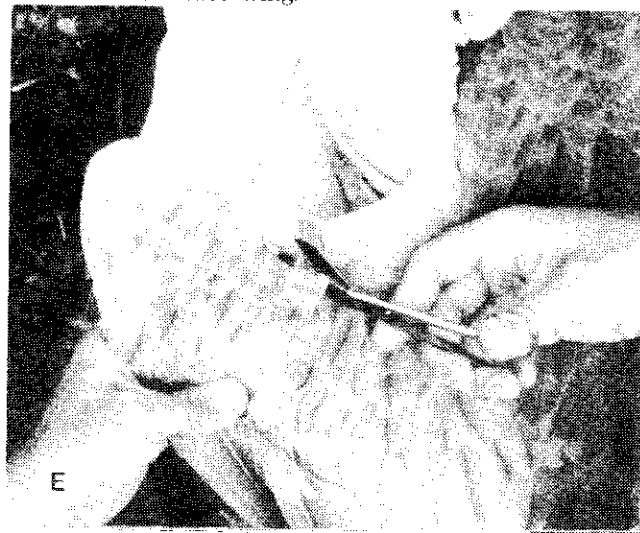
B. Wing extension capability in a properly tenotomized bird.



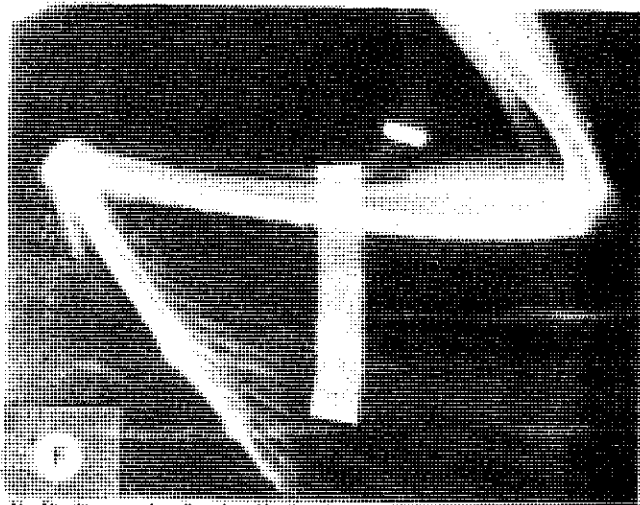
C. A wing-clipped wing.



D. A vane-trimmed wing.



E. Removing a brail.



F. Radiograph of a tenotomized wing.

Figure 1. Flight restraint in cranes.

When brailing a crane, one caretaker holds the bird immobile while a second inspects the wing to be certain that less than 4 cm of the rachis of each primary is still in the blood. If the blood filled zone in some of the quills is more extensive than 4 cm, brailing is postponed to avoid damage to the growing feathers. If the bird is ready to be brailed, the brail is inserted between the bases of the third and fourth most distal primaries (numbers 7 and 8), and the strap is formed into a loose loop over the patagium. Alternately, rather than being inserted between the primaries, the brail loop may enclose all 10 of the primaries. With the wing folded, the rivet, with one washer on the shaft, is placed through two of the pre-drilled holes in the brail. Probing upward with the free hand, a path is opened for the rivet to pass between the feathers and through a third hole in the brail on the underside of the wing. The loops above and below the rivet should be about equal size. The washer is placed on the rivet and fastened. The trailing end of the brail should point downward and be trimmed in a convex arc to within 3 cm of rivet. To remove a brail, cut the upper loop (Figure 1E) and slide the brail off the primary tips. The final positions of the brail, rivet, and body parts are illustrated in Figure 1F.

Proper fit of the brail is important. If the brail is too loose it will slide toward the humerus until the primaries are free; if too tight, it will restrict circulation in the wrist and hand. The fit is checked by placing two fingers beneath the brail on the dorsal surface of the wing in the upper loop. If the fingers slide under easily but snugly, a good fit has been achieved. If the caretaker's fingers do not slide easily under the upper loop, the brail is removed (and a new brail is fitted).

During the first 10 min or so after release, the bird usually strains at the brail, attempting to extend the wing, and

preens vigorously at the site of the brail. After a few hours, however, the bird typically gives little attention to the brail.

At the Center, we have brailed over 120 cranes that were eventually released to the wild. Many of these have survived for years after release. Occasionally, a bird shows slight but long term impairment in its ability to extend the hand of one wing following an extended brailing period. Very rarely, either the patagium or the integument between the primaries is damaged by a brail. Only once has a bird been so incapacitated in hand extension that it could not be released.

## CONCLUSIONS

Many techniques are available for temporarily and permanently restraining flight in captive cranes. In the 20 years that the Center has maintained cranes in captivity, we have settled on four techniques that we use routinely. In addition, a new technique, vane trimming, was first used in 1986. Most birds in our flock (including both cranes of endangered species that are intended for artificial insemination and nonendangered cranes that are used as research surrogates and foster parents) are tenotomized. Netted pens are routinely used for maintaining birds prior to release and are now experimentally in use to determine the importance of wing condition on natural fertility. Wing clipping and vane trimming are used for birds that are not intended to fly for 2 to 3 years, or for birds that will be tenotomized in the ensuing months. Wing clipping is also used for birds that are tenotomized but still capable of escaping pens. Brailing is used frequently for many purposes. These techniques are an integral part of the management of our crane colony.

## ACKNOWLEDGMENTS

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## CRYOPRESERVATION OF CRANE SEMEN

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### ABSTRACT

The method for the cryopreservation of crane semen at Patuxent Wildlife Research Center is described in detail. Cryopreservation is useful for the long-term storage of crane semen and for specialized propagation needs. A 50% fertility rate from most sandhill cranes *Grus canadensis* inseminated with frozen-thawed semen can be expected. Additional research should improve the fertility rate and determine how applicable the technique is to other crane species.

### INTRODUCTION

Humanity's survival and advancement are dependent on an abundant biological diversity for ecological balance and for applications in agriculture, medicine, and engineering. Biological diversity continues to decline throughout the world and is the object of numerous preservation schemes (Myers 1979). The populations of many species are declining because of the destructive exploitation of our natural resources, resulting in shrinking habitats. The fate of most of these small, closed populations is the loss of genetic diversity and, eventually, extinction (Senner 1980).

The preservation of plant and animal gene pools is not a new concept and has received widespread attention in recent years (U.S. Department of State 1982). The captive propagation and study of cranes at the Patuxent Wildlife Research Center (PWRC) includes two endangered species — the whooping crane *G. americana* and the Mississippi sandhill crane *G. canadensis pulla*. Programs at PWRC attempt to thwart the further decline in genetic diversity of these species. These cranes are used for scientific research, production of stock suitable for release to the wild, and as insurance against a calamitous loss of populations in the native habitat (Carpenter 1977; Derrickson and Carpenter 1987).

The relatively small captive crane populations at PWRC are in need of gene pool protection. Selective breeding programs are used to maintain genetic diversity but these efforts are limited by the number and relationship of individuals in the flock. To preserve the gene pool, a study of semen cryopreservation began in 1976 (Sexton and Gee 1978; Gee and Sexton 1979). Techniques were developed from 1976 to 1980, and collection of semen for a frozen semen bank from whooping and Mississippi sandhill cranes began in 1981. The collection, preparation, and cryopreservation of crane semen are the subject of this report.

### COLLECTION AND TRANSFER TO LABORATORY

Crane semen is collected by the massage method (Archibald 1974; Gee and Temple 1978) and is diluted 1:1 with

a modified Beltsville Poultry Semen Extender (Sexton 1977) especially prepared for crane semen (Gee et al. 1985). The semen sample is held at ambient temperature for 1 - 2 min in order to measure the sample and add the extender. The sample is then placed in a small (2-ml) pointed tube. A wax film is placed over the opening to the tube, tightly enough to protect it from contamination and loosely enough to allow for some exchange of air. The tube is labeled for identification and to provide necessary pedigree information.

The 2-ml tube is placed in a slightly larger (4-ml) round-bottomed tube, and the two tubes are placed vertically in a rack in a cool ( $\leq 5^{\circ}\text{C}$ ), insulated water bath. The shallow water covers the bottom of the rack holding the tubes and the lower inch of the tubes holding the semen. The tube-in-tube arrangement slows the heat loss from the semen to the surrounding cold water. The top of the insulated water bath is closed between sample collections to reduce the effect of sunlight on the semen, to exclude airborne contaminants, and to help maintain the desired temperature. Under these conditions, a few cubes of ice are all that are necessary to keep the water cool. Generally the semen samples are transferred to the laboratory an hour after collection. In some semen samples, especially those contaminated by feces or urates, sperm motility and percentage live cells decline substantially when held for more than one hour. Good samples, however, can be held in this manner for up to three hours before freezing.

### SAMPLE PREPARATION

The extender, equipment, and supplies are prepared before the samples are collected. Everything used to collect, transfer, or hold semen must be clean and dry. This includes a thorough rinsing with distilled water to remove any traces of soap and other contaminants, and oven drying to remove any trace of water. A 1-ml syringe with an open-ended tom cat catheter (3-1 2 FR, 5-1 2 in) or something similar is necessary to dilute and transfer samples.

Plastic 0.5-ml semen straws and canes to hold the straws are prepared in advance. Canes are labeled with the current year and numbered consecutively. For example, the 15th sample frozen in 1984 would be labeled 84-15. Information printed directly on the semen straw indicates the source of the sample (e.g., PWRC, Endangered Species Research Program) and the animal's identification (e.g., species and permanent bands or tattoo).

When the samples are brought to the laboratory, the cryoprotectant solution (18% dimethyl sulphoxide [DMSO] in crane extender) is taken from the refrigerator and placed in the water bath with the samples. The temperature of the cryoprotectant solution and semen samples equilibrate during the evaluation, measuring, and recording processes. Also, the temperature of the ethanol bath into which the canes will be placed for freezing is adjusted to 5°C, as measured by a temperature probe that was constructed earlier. The probe is made by inserting a Type T bimetal thermocouple into a semen straw containing 6% DMSO in crane extender and sealing it with a vinyl plastic putty. The probe is mounted on a semen cane and placed in the ethanol bath. The temperature recording unit is a Honeywell<sup>1</sup> Electronik III, Type T recorder with a range from 5°C to -200°C.

A small portion of each sample is examined for motility and concentration when the samples are brought into the laboratory. The volume of good samples (Gec and Temple 1978) is measured and recorded in the preservation log, and poor samples are discarded. Good samples are assigned cane numbers and entered in the log; the appropriate cane and straw are selected. One end of the open-ended straw is heat sealed and added to the appropriate cane.

After the evaluation, measuring, and recording process, the cryoprotectant solution (18% DMSO) is added to the semen sample. To obtain a sample containing 6% DMSO and a semen-to-extender ratio of 1:2, 0.5 part cryoprotectant solution is added to 1 part diluted semen. Each sample, except for a residual (0.005 ml), is transferred to the plastic straw. The open end of the straw is heat sealed, added to the cane, and the cane placed into the ethanol bath. The residual from each sample being frozen is used to make three 5% eosin - 10% nigrosin stained slides (live-dead stain, Burrows and Quinn 1939). As determined from these slides, samples with 90% or better live cells are stored for future use and the others are discarded. In an alternative evaluation method often used with more valuable samples, the residual can be placed in a small plastic straw (0.2 ml), sealed, placed on a cane, and frozen with the other samples. A live count and motility score are made from the frozen-thawed residual sample. If frozen-thawed residuals show 40% or fewer live cells, the larger samples are discarded.

#### CRYOPRESERVATION

The sample is frozen sequentially in ethanol, in liquid nitrogen vapor, and finally in liquid nitrogen. The Cryocool<sup>2</sup> probe (a refrigeration compressor immersion probe), stirrer, and the recording thermocouple are started after the last sample is placed in the ethanol bath. The liquid phase

of semen freezing, from addition of DMSO to the formation of ice, requires 15 to 30 min. A 15-minute-plus equilibration time is necessary to obtain the maximum cryoprotectant effect from DMSO with the least amount of cell toxicity. The probe, stirrer, and samples are submerged in the ethanol bath, which consists of an insulated tank (U-tainer<sup>3</sup>). The small laboratory stirrer is necessary to maintain a constant temperature throughout the ethanol and around each semen cane. The first phase of the freezing process reduces the semen temperature from 5°C to -20°C at the rate of 1°C per min (25 min).

While the semen is freezing in the ethanol, a vapor tank is filled with 5 cm of liquid nitrogen. The vapor tank is used in the second and third stages of the freezing process. The semen canes are removed from the ethanol bath when they have reached -20°C and the ethanol is shaken out of the canes. The canes are laid horizontally in the basket of the vapor tank, above the liquid nitrogen. The transfer is completed quickly to avoid an increase in sample temperature. When the samples reach -80°C (about 2 min), the entire basket (thermocouple and samples) is plunged into the liquid nitrogen in the bottom of the tank. By using this system, the semen is frozen at a rate of 1°C per min (+5°C to -20°C), 50°C per min (-20°C to -80°C), and 160°C per min (-80°C to -196°C). The samples remain in the vapor tank for 5 min before transfer to the appropriate position in the liquid nitrogen storage tank. The samples are stored in liquid nitrogen and as a safeguard, an alarm on the storage container is used to indicate low liquid level.

#### USE OF FROZEN SEMEN

To use frozen samples for insemination, the canes are transferred from the storage tank to a portable liquid nitrogen tank for transport. When needed, the cane is removed and completely immersed in an ice bath (crushed ice saturated with water, 0.5°C) until the semen is thawed (3 to 5 min). Identification of the semen straw is confirmed after thawing and the semen is drawn into a syringe through a catheter, similar to that used for handling fresh semen described above.

The insemination process with frozen-thawed semen is the same as that used with fresh semen (Gec and Sexton 1979). A small portion, however, is taken from the frozen-thawed semen by a capillary tube. Three eosin-nigrosin stained slides are made at the time of insemination, and the remainder of the capillary tube examined later in the laboratory for motility. In addition, the equivalent of three ejaculates are used for each insemination to compensate for the loss of cells during freezing (about 50%) and the loss of semen on the sides of tubes, straws, and transfer

<sup>1</sup>Honeywell, Industrial Division, 1100 Virginia Avenue, Fort Washington, Pennsylvania 19034, U.S.A. Mention of this or any other commercial product does not constitute endorsement by the U.S. Government.

<sup>2</sup>Cryocool probe, Neslab Instruments, Inc., 871 Islington Street, Portsmouth, New Hampshire 03801, U.S.A.

<sup>3</sup>U-tainer, insulated multipurpose baths, Neslab Instruments, Inc., 871 Islington Street, Portsmouth, New Hampshire 03801, U.S.A.



devices. If the ejaculations are small, a fourth sample may be required to obtain the 15 to 20 million live cells per insemination necessary to obtain good fertility (Gee et al. 1985).

#### INVENTORY SYSTEM

An inventory system is helpful in finding samples and in determining the accumulated semen pool for each animal. Although each straw is labeled with complete pedigree information, only the cane number (recorded in the preservation log) is accessible during storage. The preservation log is too cumbersome to use to find a sample or to determine the number of frozen semen samples available from an individual bird. The inventory is therefore composed of two additional records, kept concurrently with the preservation log — a pedigree locator and a cane locator.

Both locators contain complete pedigree information, date of freezing, semen volume, cane number, and cane location in the bank. The pedigree locator lists canes by bird and their bank location. The cane locator lists canes by storage container and section, and their pedigree information. From the locators, the cumulative number of samples stored and the total semen volume are recorded annually for each bird. A heavy dark line is drawn through entries in the two locators when the sample is removed, and the date and use of the sample is recorded. Semen motility and percentage of live spermatozoa are recorded in the preservation log if the sample is used locally.

#### FUTURE NEEDS

With the techniques described, 50% fertility rates from cranes inseminated with frozen-thawed semen are ex-

pected. Additional studies should increase fertility rates to the 65% achieved in chickens (Sexton 1976). In addition to fertility testing of semen at higher DMSO levels, the technique described should be tested in other species of cranes. Semen pH and osmolality in other crane species may differ; these values need to be determined and the diluent adjusted accordingly. Alterations in the diluent may change the optimum conditions of several other factors such as DMSO concentration, storage time and temperature, semen dilution, DMSO equilibration time, freeze rate, and thaw rate.

A universal curatorial procedure needs to be established for frozen semen banks; where possible, this should be done in accordance with traditional procedures for systematic collections. At a minimum, the inventory should contain species, exact location, collection date, preparation method, voucher specimen location, and the names of the person or institution that contributed the sample. A centralized computer inventory program for all banks would improve access to samples. Because samples are used and not returned, a method of reimbursement to the supplier would be beneficial. An advisory committee should be established to recommend changes in existing procedures, to be a source of up-to-date information on the technical aspects of preservation, and to help coordinate the storage of semen in various regional centers. As insurance against catastrophic loss, semen from each animal should be stored at several locations.

Although semen storage studies indicate that semen can be stored for long periods (Mazur 1980), no long-term storage studies (100 years or more) are in progress. Innovative research is needed to determine the probable storage life of sperm cells in liquid nitrogen.

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Baraboo, Wisconsin, USA