

Crane Research Around the World:

**Proceedings of the International Crane
Symposium at Sapporo, Japan in 1980
and Papers from the World Working
Group on Cranes, International Council
for Bird Preservation**

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1981



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**International Crane Symposium at Sapporo, Japan
Sponsored by:**

**International Council for Bird Preservation (ICBP)
International Waterfowl Research Bureau (IWRB)
Wild Bird Society of Japan (WBSJ)
International Crane Foundation (ICF)**

Publication Funded by

**Mary Livingston Griggs and Mary Griggs Burke Foundation
and**

International Council for Bird Preservation

**Available from
International Crane Foundation
City View Road
Baraboo, WI 53913**

\$15.00

WBSJ



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PREFACE

This publication was first envisioned in 1974 by Dr. George W. Archibald, Co-founder of the International Crane Foundation located in Baraboo, Wisconsin. As Chairman of the Crane Working Group of the International Council for Bird Preservation, Dr. Archibald invited papers from members of the Working Group and other scientists knowledgeable about cranes. Other work obligations and insufficient funds prevented prompt publication of the manuscripts. Dr. Marie Rowlands Oesting translated and edited some of the manuscripts first received in the mid-1970's and stimulated the search for financial support for this publication. Her substantial assistance is greatly appreciated.

I was asked to edit the manuscripts submitted for Crane Research Around the World and those presented at the International Crane Symposium held 21-22 February 1980 in Sapporo, Japan. This publication includes 20 papers presented at the Sapporo Conference and 28 papers originally written at various times between 1974 and 1981. Most of the papers written in the mid-1970's have been revised and updated or, if not, the time restrictions of the material are indicated within each article.

Co-editor Dr. Hiroyuki Masatomi did an excellent job of reviewing and, when needed, translating all papers presented by Asian Scientists at the meeting in Sapporo. I edited all papers and, where appropriate, changed the terminology to that I believed most characteristic of American scientists. To expedite publication, authors were not given the opportunity to review the printer's copy. Thus, any errors are fully my responsibility. I thank the Office of Biological Services, U.S. Fish and Wildlife Service, for the opportunity to participate in this effort and, thereby, contribute to conservation of the world's crane species--J. C. Lewis.

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*Articles followed by an asterisk were presented at the Sapporo, Japan, conference.

Whooping Crane

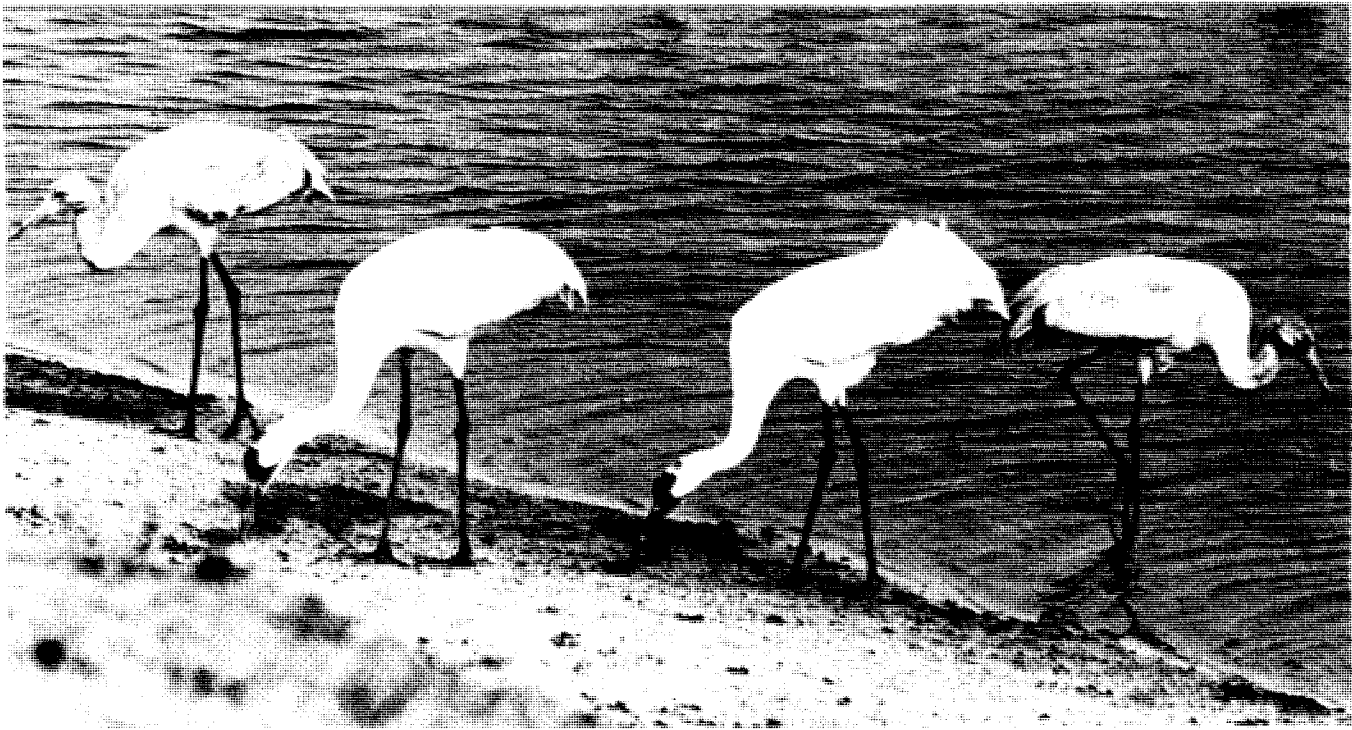


Photo courtesy U.S. Fish and Wildlife Service.

THE WHOOPING CRANE

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This report summarizes, from the literature and from contemporary research and management, information on the whooping crane (*Grus americana*) and discusses actions deemed necessary to prevent the extinction of this species. Robert Porter Allen (1952, 1956) described in authoritative detail the whooping crane's prehistoric and historic population levels, distribution, life history, ecology, and factors leading to endangerment, and frequent reference is made to his work. Other publications of particular note are Faith McNulty's (1966) *The Whooping Crane*, which provides a popular, factual account of the whooping crane's decline and early preservation attempts; and N. S. Novakowski's (1966) *Whooping Crane Population Dynamics on the Nesting Grounds, Wood Buffalo National Park, Northwest Territories, Canada*, which describes the breeding grounds and summarizes production from 1954 to 1965.

Bob Allen warned of the whooping crane's desperate plight and advocated more sustained, purposeful actions to prevent its extinction. The reactions of the public, the wildlife manager, and the research biologist to Allen's challenge are detailed in this paper.

PHYSICAL DESCRIPTION

The whooping crane (Fig. 1) is the tallest North American bird; males approach 1.5 m when standing erect and exceed the greater sandhill crane (*G. canadensis tabida*) in height by 0.12 to 0.20 m. Males are generally larger than females, and weights of adult birds in captivity have averaged 7.3 kg for males and 6.4 kg for females. Seasonal weight variation is considerable, with a maximum occurring in December and January and a minimum in July and August. External measurements from preserved specimens have been summarized by Walkinshaw (1973:166).

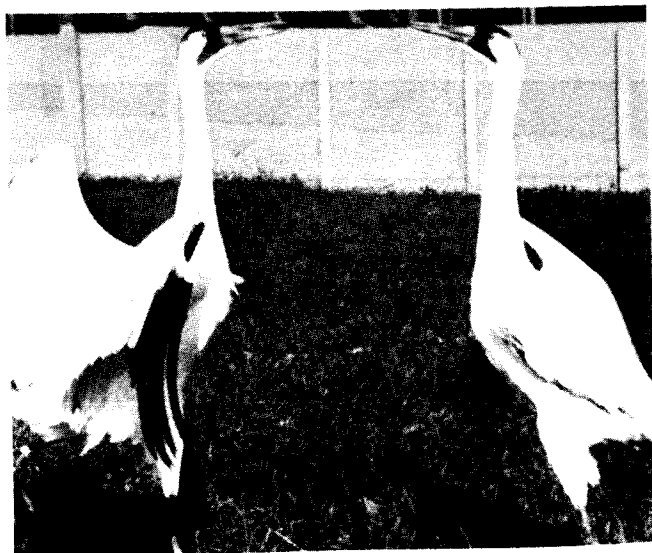


Fig. 1. An aggressive encounter by 2 yearling whooping cranes establishing their position in the dominance hierarchy at the Patuxent Wildlife Research Center (R. C. Erickson).

Plumage of the adult is snowy white except for black primaries, black or grayish alulae, sparse black bristlelike feathers on the carmine crown and malar region, and a dark gray-black wedge-shaped patch on the nape. The size of the postoccipital patch varies considerably between individuals. When standing with wings folded, the black primaries and alulae are hidden from view, and the plumed, decurved tertials ordinarily conceal the short tail. The strong bill is a dark olive-gray, which becomes lighter during the breeding season. The area at the base of the bill is pink or rosaceous, and the iris of the eye is yellow. The legs and feet are gray-black, although the ventral surfaces of the toes are a dull flesh or salmon color.

Recorded weights of chicks hatched in captivity from wild eggs range from 107 g to 145 g (\bar{x} = 124.4, SD 12.0, SE \pm 2.1, N = 32) following emergence and drying. The newly hatched chick is about 18 cm in height (Fig. 2). The bill is flesh-pink; the legs and toes are either a light pinkish-brown or a light gray-brown with a pinkish band at the tibiotarsal joint. Body down varies from a rich cinnamon or sayal brown along the medial line of the crown, neck, back, and wings, to a lighter pale cinnamon below. Much of this rich coloration is lost as the down feathers lengthen, exposing darker grayish bases. The emerging contour feathers begin to restore the reddish cinnamon color when the chick is about 4½ weeks old, and continued extension of the white feather bases gives a beautiful mottled appearance, especially when the wings are spread. By this time the originally dark brown iris is a light blue-gray.

At about 3 months (75-100 days) the chick is capable of sustained flight, and by 4 months completely white feathers begin to appear on the base of the neck and back (Fig. 3). The replacement of the juvenile plumage continues through the winter and varies considerably among individuals. By the following spring the plumage is predominantly white and the dark crown, lores, and malar areas are apparent. Rusty vestiges remain only on the head, the upper neck, and in the scapular region. Yearlings achieve a typically adult appearance by late in their second summer or fall.

Molt of the black primaries first occurs at 2 years of age and is believed to occur annually thereafter during mid-summer. Observations of wild individuals at Grays Lake National Wildlife Refuge in Idaho (R. C. Drewien, pers. comm.) and captives at Patuxent Wildlife Research Center suggest that an extensive or simultaneous loss of remiges, resulting in flightlessness, may be typical. Whether all individuals become flightless during the wing molt, however, remains uncertain. The pattern of remigial molt is extremely variable in sandhill cranes (Lewis 1979), and future studies may reveal similar variations in whooping cranes.

STATUS

Inclusion of the whooping crane in the United States "List of Endangered and Threatened Wildlife and Plants" (Title 50, Code of Federal Regulations, Part 17) implies an imminent danger of extinction if man-

agement is unsuccessful in assuring its preservation. Following a thorough examination of extant records, Allen (1952:83) estimated that the whooping crane population "in recent times, and down to 1860, or possibly 1870, totalled between 1300 and 1400 individuals." Although the accuracy of this often quoted figure can legitimately be debated, the available evidence clearly indicates that the whooping crane was uncommon and its numbers rapidly declining by late in the 19th century. By 1937, only 2 small breeding populations remained--a sedentary population that inhabited the area around White Lake in southwestern Louisiana, and a migratory population that wintered on the newly established Aransas National Wildlife Refuge in coastal Texas. The remnant Louisiana population was reduced from 13 birds to 6 birds following a severe storm in August 1940, and the last surviving individual was taken into captivity in 1948.

Accurate counts of the migratory population in Texas were obtained each winter following the establishment of the Aransas Refuge (Table 1). Although limitations on the use of aircraft between 1938 and 1947 made censusing difficult and increased the potential for incomplete counts, the only obvious disparity occurred in 1945, when the census total was less than the number of white-plumaged birds returning the following fall. An analysis of population changes and factors deemed responsible will be made in later sections of this report.

As of January 1981, there were 78 whooping cranes in the Aransas-Wood Buffalo population, 17-20 birds in the Idaho-New Mexico population, and 26 birds in captivity (22 at Patuxent Wildlife Research Center, Laurel, MD; 2 at International Crane Foundation, Baraboo, WI; and 2 at San Antonio Zoo, San Antonio, TX).

DISTRIBUTION

The whooping crane is no newcomer among North American birds. Fossilized remains dating back several million years, from the Upper Pliocene in Idaho (Miller 1944, Feduccia 1967) and from the Pleistocene in California, Kansas, and Florida (Wetmore 1931, 1956), appear inseparable from the recent form. The distribution of these remains suggests a wider distribution during the Pleistocene than during recent times. Currently available evidence indicates that the historic range extended from the Arctic coast south to central Mexico and from Utah east to New Jersey, South Carolina, and possibly Georgia and Florida (Allen 1952).

Breeding Range

The principal historic breeding range extended from central Illinois northwestward through northern Iowa, western Minnesota, northeastern North Dakota, southern Manitoba, and Saskatchewan to the general vicinity of Edmonton, Alberta (Fig. 4). A separate, nonmigratory breeding population also occurred in southwestern Louisiana. The whooping crane disappeared from the heart of its breeding range in the northcentral United States by the 1890's. The last documented nesting in the aspen parklands of Canada occurred at Muddy Lake, Saskatchewan in 1922, and the last reported reproduction in the Louisiana population occurred in 1939. Another isolated breeding population, discovered in 1954, was located in Wood Buffalo National Park, Northwest Territories, Canada (Fig. 4). This latter population was the only 1 that managed to survive.

The present nesting area within Wood Buffalo National Park lies between the headwaters of the Nyar-

ling, Sass, Klewi, and Little Buffalo Rivers. The terrain is poorly drained and is characterized by oxbowed rivers and streams and countless potholes separated by low, narrow ridges (Fig. 5). These ridges are deeply cushioned with sphagnum moss (*Sphagnum* sp.) and support an overstory of black spruce (*Picea mariana*), tamarack (*Larix laricina*), and willow (*Salix* sp.) and an understory of dwarf birch (*Betula glandulosa*) and Labrador tea (*Ledum groenlandicum*). Bulrush (*Scirpus* sp.) and sedges (*Carex* spp.) are the dominant emergents in the ponds occupied by nesting pairs and are used in nest construction. Nesting ponds average 25 cm in depth, but due to the low topographic relief, water levels vary considerably in relation to precipitation. The nesting area is described in greater detail by Allen (1956) and Novakowski (1965, 1966).

Most whooping crane pairs return to the nesting area in late April or early May, and shortly thereafter begin nest construction and egg laying. Evidence suggests that established pairs show considerable fidelity to their breeding territories and normally nest in the same general vicinity each year. These nesting territories have an average radius of 0.9-1.0 km and encompass an area of roughly 3.0-3.8 km² (Kuyt 1976 a, b; see also this Proceedings).

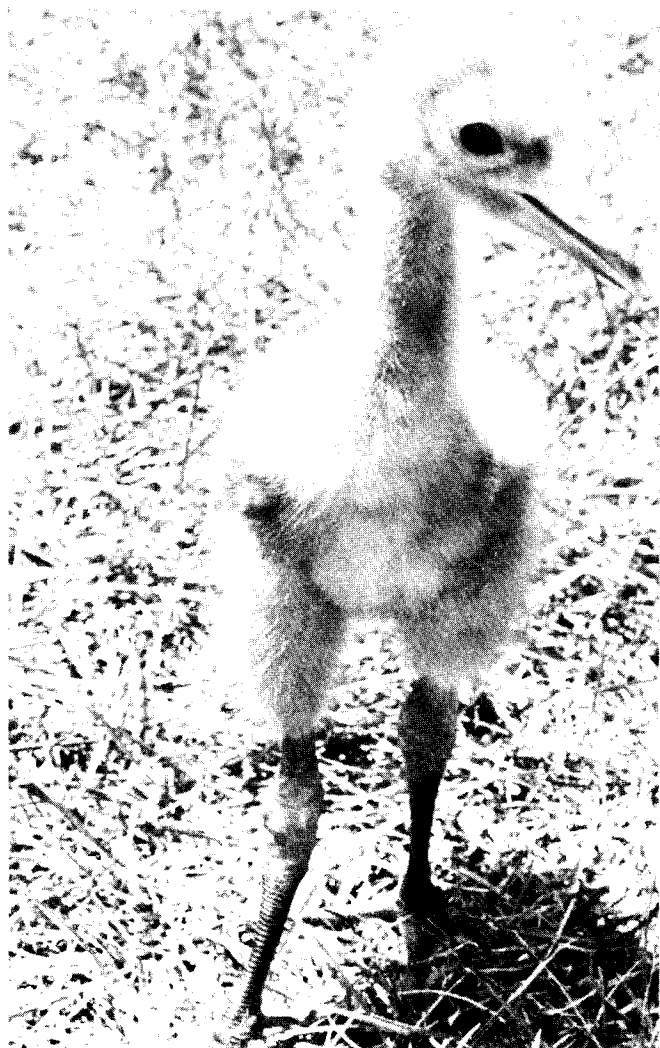


Fig. 2. Patuxent-hatched whooping crane chick 3 weeks old (R. C. Erickson).



Fig. 3. Whooping crane chick 4½ months old. Rufous-colored plumage of the back is being replaced by white feathers (G. Smart).

Migration Routes and Concentration Areas

Historically there were 4 different migration routes. The 2 most important were "those between Louisiana and the nesting grounds in Illinois, Iowa, Minnesota, North Dakota, and Manitoba, and from Texas and the Rio Grande Delta region of Mexico to nesting grounds in North Dakota, the Canadian Provinces and the Northwest Territories" (Allen 1952). Another route, deserted since 1857, across the Appalachians to the Atlantic seaboard was probably of minor significance. A route through west Texas into Old Mexico apparently followed that still used by sandhill cranes, and it is believed that whooping cranes regularly travelled with them to wintering areas in the central intermountain region (Allen 1952).

For more than 50 years, most whooping cranes have moved along a narrow corridor extending in a rather straight line from Wood Buffalo National Park to the Aransas National Wildlife refuge on the Texas coast. This route passes south-southeastward through northeastern Alberta, southwestern Saskatchewan, northeastern Montana, western North and South Dakota, central Nebraska and Kansas, west-central Oklahoma, and east central Texas. Scattered portions have been reported in many of the adjacent states and provinces.

The autumn migration normally begins in mid-September, with most birds arriving on the wintering grounds between late-October and mid-November. Nonbreeders and unsuccessful breeders probably initiate and complete migration sooner than family groups, because young-of-the-year are rarely observed among the first birds arriving in southern Saskatchewan or Texas (Allen 1952, Archibald et al. 1976, Stephen 1979).

Whooping cranes are much less gregarious than sandhill cranes and normally migrate as singletons, pairs, families, or in small flocks. However, like sandhills, they are diurnal migrants and make regular

stops to feed and rest. Although whooping cranes will use a variety of habitats for foraging and roosting during these stopovers, they seem to prefer isolated sites away from human activities. This preference, and their rarity, together result in few authenticated sightings during migration each year.

Wintering Grounds

Allen (1952) believed the tall grass prairies of southwestern Louisiana were the whooping crane's principal historical wintering range. The whoopers also occurred along the gulf coast of Texas and northeastern Mexico, primarily in the vicinity of the Rio Grande delta. Other significant wintering areas were located in the interior tablelands of western Texas and the high plateaus of central Mexico, where whooping cranes occurred among thousands of sandhill cranes; the latter still regularly winter in these locations. Whooping cranes now regularly winter only on the Aransas National Wildlife Refuge, nearby Matagorda and St. Joseph Islands, portions of the Lamar Peninsula, and Welder Point on the east side of San Antonio Bay. Some individuals also occur occasionally on nearby farmlands.

The Aransas National Wildlife Refuge is an important part of the refuge system of the U.S. Fish and Wildlife Service (Fig. 6). Along with the remaining wild population of whooping cranes, the refuge accommodates more than 300 species of birds, including white-faced ibises (*Plegadis chichi*), common (Casmerodius albus), and snowy egrets (*Leucophoyx thula*), various herons, roseate spoonbills (*Ajaia ajaja*), sandhill cranes (*G. c. tabida* and *G. c. rowani*), wild turkeys (*Meleagris gallopavo*), many species of shorebirds, and thousands of waterfowl. Other wildlife found on the refuge include coyotes (*Canis latrans*), white-tailed deer (*Odocoileus virginiana*), collared peccaries (*Pecari angulatus*), and American alligators (*Alligator mississippiensis*).

About 9000 ha of salt flats on the refuge and adjacent islands make up the principal wintering grounds during 5 months of each year (Fig. 6). Vegetation of this area is dominated by salf grass (*Distichlis spicata*), saltwort (*Batis maritima*), glasswort (*Salicornia* sp.), and salt marsh (*Spartina alterniflora*) and gulf cordgrass (*S. spartinae*). Interior portions of the refuge are gently rolling and sandy and are characterized by oak brush, cleared grassland, swales, and ponds. Typical plants include live oak (*Quercus virginiana*), redbay (*Persea borbonia*), Bermuda grass (*Cynodon dactylon*), and bluestem (*Andropogon* spp.) (Stevenson and Griffith 1946, Gunter 1950, Allen 1952, Labuda and Butts 1979). Many upland sites have been subjected to grazing, mowing, and prescribed burning during the last 20 years (Labuda and Butts 1979).

Pairs and family groups typically occupy and defend relatively discrete territories, although close association is tolerated at times on the wintering grounds. These territories average 176 ha (60-400 ha) and include suitable foraging and roosting areas (Allen 1952, Blankinship 1976). Whooping cranes are omnivorous feeders, but animal foods--especially blue crabs (*Callinectes sapidus*) and clams (*Tagelus plebius*, *Ensis minor*, *Rangia cuneata*, *Cyrtopleura costata*, *Phacoides pectinata*, and *Macoma constricta*)--predominate in the winter diet (Allen 1952, 1954; Uhler and Locke 1969; Blankinship 1976). Most foraging occurs in the brackish bays, marshes, and salt flats lying between the mainland and the barrier islands. Occasionally, however, whooping cranes will move to upland or inland sites when attracted by foods such as

acorns, insects, and agricultural crops. Farmland is particularly attractive when temporarily flooded by winter rains or burned to remove plant residues, or when food is less available in the salt flats and marshes. Considerable movement on and off the refuge occurs in most years.

As spring approaches, territorial behavior diminishes and small groups are observed more often. Dancing, unison calling (Archibald 1976), and flying increase in frequency and are especially indicative of premigratory restlessness (Allen 1952, Blankinship 1976). The northward migration normally begins between late March and mid-April, and family groups and

pairs are usually among the first to depart the refuge. Departure is assisted by strong southeast winds that typically occur at this time of year. Spring migration proceeds rapidly and encompasses a shorter time span than the southward migration in the fall.

Family groups apparently separate either en route to the breeding grounds or soon after arrival (Allen 1952, Novakowski 1966). Recent information on marked individuals suggests that most juveniles and subadults return to summer in their natal area (Kuyt 1979b, pers. comm.), though there are records of whooping cranes summering in locations away from Wood Buffalo National Park (Allen 1952, Archibald et al. 1976).

Table 1. Whooping crane populations--1938 to 1979^a.

Year	Adult-plumaged ^b	Young of year	Total	Year	Adult-plumaged	Young of year	Total
1938	14	4	18	1960	30	6	36
1939	15	7	22	1961	34	5	39
1940	21	5	26	1962	32	0	32
1941	13	2	15	1963 ^c	28	7	35
1942	15	4	19	1964	32	10	42
1943	16	5	21	1965	36	8	44
1944	15	3	18	1966	38	5	43
1945 ^d	14	3	17	1967	39	9	48
1946	22	3	25	1968	44	6	50
1947	25	6	31	1969	48	8	56
1948	27	3	30	1970	51	6	57
1949	30	4	34	1971	54	5	59
1950	26	5	31	1972	46	5	51
1951	20	5	25	1973	47	2	49
1952	19	2	21	1974	47	2	49
1953	21	3	24	1975	49	8	57
1954	21	0	21	1976	57	12	69
1955	20	8	28	1977	62	10 ^e	72
1956	22	2	24	1978	68	7	75 ^f
1957	22	4	26	1979	70	6	76
1958	23	9	32	1980	72	6	78
1959	31	2	33				

^aAdapted from a USDI news release of 14 April 1974, entitled "Whooping Crane Population Summarized." Totals in each category represent the number of birds known to reach the Texas wintering grounds each year. This table does not include either the nonmigratory population in Louisiana (1938, 11; 1939, 13; 1940, 6; 1941, 6; 1942, 5; 1943, 4; 1944, 3; 1945, 2; 1946, 2; 1947, 1; 1948, 1) or the migratory Idaho-New Mexico population currently being established by cross-fostering (1975, 4; 1976, 6; 1977, 8; 1978, 9; 1979, 15; 1980, 17 to 20).

^bYoung of the year are recognizable by their juvenile plumage but after their first year cannot be distinguished from adults. Consequently, the category "adult-plumaged" includes sexually immature as well as sexually mature individuals.

^cIncludes 2 birds reported near Tampico, Mexico, by Game Agents Frazier and Hogue.

^dThe 1945 census of Aransas and vicinity was 14 and 3; however, since 22 white-plumaged birds returned to the wintering grounds in 1946, it is evident that some birds were not counted in 1945.

^eIncludes 1 bird not spending its 1st winter at Aransas NWR but observed in the spring of 1978 during its northward migration.

^fOne juvenile disappeared soon after arrival on wintering grounds, and the population peaked at 74 birds.

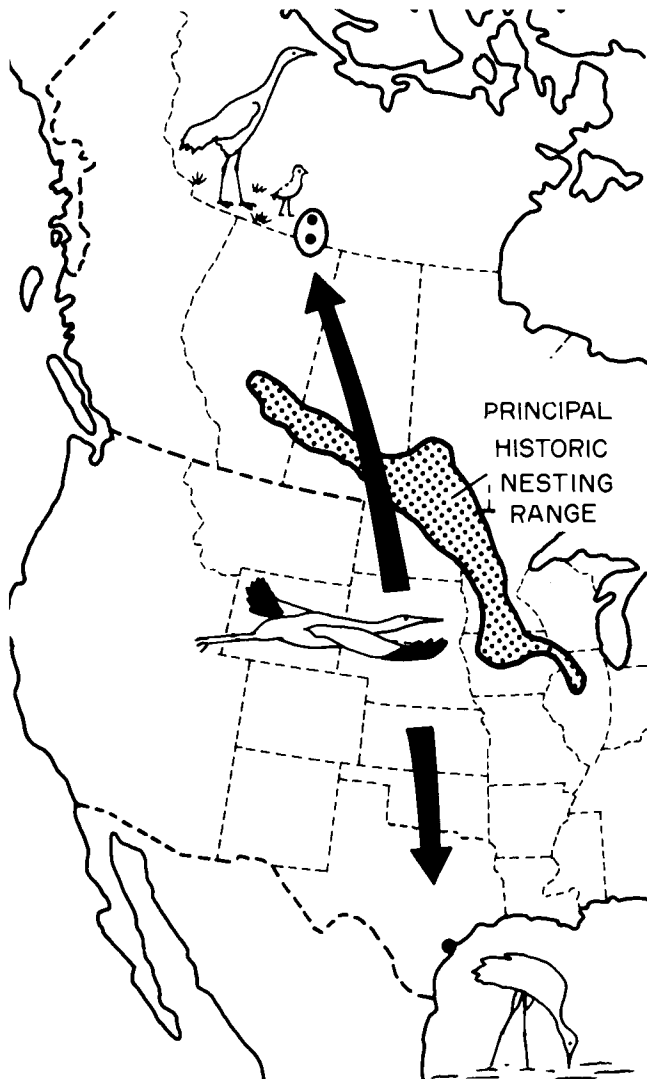


Fig. 4. North American areas of principal historic use by whooping cranes (Original map by Dr. Angela K. Kepler).

FACTORS LEADING TO ENDANGERMENT

The impact of human settlement upon the wildlife of the interior of North America is dramatically evident in the changing status of 2 large white birds, the whooping crane and trumpeter swan (*Olor buccinator*). Both species disappeared from these areas as agriculture claimed the northern Great Plains of the United States and the prairie provinces of Canada. Only those remnant populations that happened to be remotely located, and for the most part away from man, managed to survive. Preservation of the Red Rocks Lakes population of trumpeter swans in southwestern Montana may have been the result of protection from hunting provided them because of the economic value of their offspring as stock for zoos and aviaries (Banko 1960). However, in this population, the remoteness of their limited breeding and wintering areas must have helped carry them through the years before legal protection became a reality.

Ironically, the same bonds of tradition that appear to have saved the whooping crane as a small, relict breeding population in the northern part of Wood Buffalo National Park prevent its voluntary return to

what was once its principal range in the northcentral United States and southern prairie provinces. These more southerly locations now contain refuges that could provide isolation from human intrusion, shorter migration distances, abundant food supplies, and time for renesting if initial nesting attempts were unsuccessful. Recolonization of these former breeding areas remains unlikely, however, unless man assists with purposeful transplantings, as he has done with trumpeter swans and Canada geese (*Branta canadensis*).

Allen (1952, 1956) has described in detail the factors restricting growth and survival of whooping crane populations, understandably without an attempt to quantify the influence of any single agent of mortality. A summary of these factors, and the possible role of each in reducing whooping crane numbers during the past 150 or more years, is presented below.

Biological Characteristics

Many aspects of the life history and population biology of whooping cranes remain uncertain because they have not been individually marked until recently (Kuyt 1978a, 1979a). As is true of other cranes, adults are potentially long-lived and sexual maturity is delayed. Current estimates suggest a maximum longevity in the wild of 22-24 years (Binkley and Miller 1980), but captive individuals are known to have survived considerably longer. Josephine was at least 27 years old at the time of her death at the Audubon Park Zoo in New Orleans, Louisiana. Another bird, a male named Crip, was brought into captivity in 1949 as a sexually mature adult (McNulty 1966) and is believed to have been at least 34-35 years old at the time of his death on 17 March 1979. A captive bird that was kept by Lord Lilford at Lilford Hall, England, was reported to be at least 40 years old (Moody 1931).

Although the average minimum age of breeding in the wild is unknown, both plumage and behavioral development suggest that individuals reach sexual maturity when 4 to 6 years old. At the Patuxent Wildlife Research Center, several captive males have produced viable semen between 3 and 4 years of age, and 1 female produced eggs in her 5th year.

The mating system of the whooping crane is characterized by monogamous, lifelong pair bonds. Although individuals will evidently remate following death of their mate (Blankinship 1976), information on initial pair formation attempts is currently lacking. Whooping cranes normally lay 2 eggs per clutch (Kuyt 1976c), but like other cranes are indeterminate layers and will renest if their 1st clutch is destroyed or lost before mid-incubation. Both sexes share incubation and brood-rearing duties (Walkinshaw 1965, 1973), but females appear to take the primary role in feeding and caring for the young (Blankinship 1976).

Delayed sexual maturity and small clutch size preclude rapid population recovery following setbacks. The current northern breeding grounds may be another handicap to productivity because the ice-free season is only 4 months long. During that time, pairs must incubate their eggs for 30-31 days and rear their chicks to flight age in about 3 months. Consequently, there is rarely time to lay a 2nd clutch and fledge young if the 1st clutch fails, as would be possible for cranes nesting farther south.

During the years that whooping cranes have been surveyed on the breeding grounds, about 1 of every 4 chicks hatched has survived to reach the Texas coast. Because no intensive studies have been made on the

breeding grounds, the factors operating to limit chick and juvenile survival remain open to conjecture. However, as pointed out by Kuyt (1976a), most mortality occurs soon after hatching and chicks that survive to flight age have a high probability of successfully completing their 1st migration. Much of this immediate posthatching mortality may be related to sibling aggression and short-term food shortage, because eggs hatch asynchronously and the precocial young are extremely aggressive toward their siblings. Brood size is rapidly reduced during periods of food shortage (Miller 1973, Drewien 1973) because the dominant chick obtains principal access to the food made available by the parents. Prolonged food shortage and predation may account for additional mortality.

Available information suggests that subadult whooping cranes may suffer rather extensive mortality in some years. These losses of juvenile and maturing nonbreeders represent a significant drain on potential production and population because they reduce recruitment into the adult population.

Little is known about the importance of diseases or parasites as mortality factors. At the time of his capture in Wood Buffalo National Park, after dislocating his wing (Novakowski 1965), CAN-US was found to be infested with coccidia. Coccidia have been found in whooping crane droppings collected on the wintering grounds (Forrester et al. 1978) and have caused the deaths of several whooping crane chicks that were being foster-parent reared at the Patuxent Wildlife Research Center (Carpenter et al. 1980). Fecal accumulations and concentrations of coccidia oocysts at brooding sites on the breeding grounds may infect pre-flight birds. Due to the stress of rapid growth and to the absence of acquired immunity, chicks may be especially vulnerable to attack by these organisms. However, the defense of large territories and small brood size ensures low-density use of the natal area and thereby reduces the likelihood of these organisms being ingested in quantity.

Weather and Habitat Conditions

The location of the nesting grounds above latitude 60° N imposes a short breeding season, the effects of which have been described previously. Several snowstorms may occur late in the spring after pairs begin to arrive, and early in the fall before departure. Hailstorms during the summer are unusual and of unknown consequence. Heavy precipitation or rapid snowmelt may subject the nesting area to flooding due to its low, poorly drained topography. Flooding of nests, however, is thought to be rare, if it occurs at all. Drought may represent a far greater hazard, because the attractiveness of traditional nest sites would be reduced, food supplies would be diminished, and newly hatched chicks would be forced to travel long distances to available wetland areas. Drought conditions would also expose nests, eggs, and chicks to terrestrial predators, whose movements would be enhanced. Potential predators in the locality include the black bear (*Ursus americanus*), wolverine (*Gulo luscus*), gray wolf (*Canis lupus*), red fox (*Vulpes fulva*), lynx (*Lynx canadensis*), and raven (*Corvus corax*), although these species are generally uncommon in the nesting area during the spring and summer. At the present time, the overall impact of predation on the breeding grounds is unknown.

Another problem closely related to drought is uncontrolled fire. The nesting area is located far from existing roads and human activities, and consequently lightning is the principal cause of fire. Because



Fig. 5. Sass River area of whooping crane nesting grounds in Wood Buffalo National Park, Canada, with helicopter in foreground (Luther C. Goldman).

pond surfaces are the dominant feature of the landscape, fire becomes a serious hazard only when it coincides with severe drought. Although the risk of fire is occasionally high, conditions on the breeding grounds reduce their vulnerability. Pairs tend to select nest sites well away from shorelines within stands of emergent vegetation and, while building and maintaining the nest structure, clear most plant cover from around the nest. Fires have burned portions of the nesting area in the past, but losses of eggs, chicks, or adults have not been documented. However, molting adults and flightless chicks could be extremely vulnerable to fire, due to their reduced mobility.

Allen (1956) found no shortage of invertebrates, primarily mollusks, crustaceans, and aquatic insects, in the ponds occupied by nesting pairs. He also reported encountering several species of minnows, frogs, and garter snakes (*Thamnophis* sp.) and believed that mollusks and frogs must be important items in the diet of breeding adults and their offspring. Novakowski (1966) did not share this belief and suggested that periodic food shortages may occur. The fact that nesting pairs rarely succeed in rearing 2 chicks supports this hypothesis.



Fig. 6. View of the tidal flats of Aransas National Wildlife Refuge on the Texas coast (Photo by Aransas staff).

Although the quality of nesting habitat can be debated, there is no evidence that growth of the wild population is being limited by available habitat. Hatching success is high in most years (Kuyt 1976a), and the area is remote from human activities. To human eyes, thousands of acres of unoccupied, but superficially similar, habitat are available in the general area. In fact, as the population has increased in recent years, some breeding pairs have become established in areas that were formerly unused (Kuyt 1978b).

In migration, whooping cranes are exposed to various natural obstacles and problems. Snow and hail storms, low temperatures, and drought can provide navigational handicaps or reduce food availability. However, whooping cranes are capable of sustained flight, and travel largely at high altitudes well out of the range of surface obstructions.

Hurricanes, heavy precipitation, and drought can create problems on the wintering grounds. Fortunately, the hurricane season usually ends by the 1st week in October, before birds normally arrive at Aransas. A very late hurricane could, however, pose considerable risk to the cranes because it is not unusual for wind velocities to exceed 100 knots. Such storms may be accompanied by high tides that could sweep the coastal flats and cause severe flooding. Heavy rainfall and drought can influence the availability and abundance of the natural food supply by altering the salinity of the tidal basins and estuaries (Blankinship 1976).

Man-associated Mortality Factors

Directly or indirectly, man appears to have been chiefly responsible for the jeopardized status of all threatened wildlife species in the United States. Our use of the term "mortality" in the following discussion refers not only to the loss of individuals but also to the decline of the species. It is treated under 3 categories: human disturbance, habitat modification, and hunting and specimen collecting.

Human Disturbance.--The whooping crane is by nature extremely wary and does not remain long near human activity. Most captives remain aloof and merely tolerate man's presence to the extent that their captivity requires. The same trait applies in the wild, apparently accounting in part for the remoteness of nesting areas, wintering grounds, and migration stopover points. However, human disturbance is tolerated when it is of short duration and does not involve obvious danger. On the wintering grounds, the birds show little concern for the tourist boat "Whooping Crane," which ferries visitors along the Intracoastal Canal for observation and photography.

Both whooping cranes and sandhill cranes are distrustful of aircraft, particularly helicopters, and seem especially fearful of attack from above. However, during the years that whooping crane eggs have been gathered from wild nests in Canada, the breeding pairs have exhibited a declining concern for approaching aircraft. They seem to have learned that there is little to fear, and consequently return to the nest soon after the human visitors have departed.

We can only surmise the extent to which settlement of the midcontinental prairies and mere human presence, as opposed to habitat alteration, may have interfered with continued use of agricultural land by breeding whooping cranes. These large, conspicuous birds could not have remained long in any settled area

without drawing the attention of someone who would wish to reduce them to objects of closer inspection or even meat for the table. One or 2 attempts to do so should have alerted the survivors to the dangers of man's presence.

Habitat Modification.--The impact of man's conversion of pothole and prairie to hay and grain production made nearly all of their original range unsuitable for whooping cranes. Disruptive practices included draining, plowing, sowing, cultivating, harvesting, and all of the human activity associated with these operations. The advent of rural electrification brought in power lines that are known to have accounted for the deaths of at least 2 migrant whooping cranes during the 1960's. On the wintering grounds, oyster shell dredging to provide road surfacing has been feared by some to be jeopardizing the barrier islands or sand reef. Such dredging may also create turbidity and siltation, which could adversely affect existing plant and invertebrate populations.

Environmental pollution appears to be creating hazards for the whooping crane and many other living things. For example, the transporting of petroleum products and other chemicals by barge along the Intracoastal Canal has for many years been considered a potential danger to whooping cranes and other wildlife at the Aransas Refuge. During the summer of 1974, 25 to 50 barrels of crude petroleum leaked from a barge. The high viscosity of the oil, and the prompt action by clean-up crews, limited the spill to a band averaging about 5 feet wide and extending about 10 miles along the canal. One whooping crane that remained all summer on the refuge stayed away from the spill area. No evidence of contamination remained by the time that the fall migrants arrived. This spill, and other more recent ones, emphasize the hazards that accompany the shipping of dangerous cargoes on the Intracoastal Canal. Petrochemical industries, and oil and gas exploration along the Gulf Coast, however, will undoubtedly increase over the next few decades.

One might expect that agricultural chemicals draining from nearby cropland would contaminate coastal habitats. However, all whooping crane egg and tissue specimens that have been examined for pesticide residues at the Patuxent Wildlife Research Center have shown concentrations well below those encountered in most other migratory birds (Robison et al. 1965, Lamont and Reichel 1970, Anderson and Kreitzer 1971). Consequently, there is no reason to believe that pesticidal contamination has adversely affected the welfare of the whooping crane.

Hunting and Specimen Collecting.--Allen (1952) prepared a detailed compilation of whooping crane specimens known to have died from gunshot or other causes from colonial times to 1948. He found that most known losses (about 66%) occurred during migration, especially between the 1880's and 1920's. Enactment of protective legislation has coincided with a decline in observed human-caused mortality. The most recently reported hunting loss was an adult female that was mistaken for a snow goose on 4 January 1968 near the Aransas Refuge boundary. The hunter is reported to have paid \$500 and court costs for his error.

Allen (1956) reported that nearly 200 live-mounts, study skins, and skeletons, and an undetermined number of eggs are in museums in the United States and Canada. Hahn (1963) reported that 309 mounts and 9 skeletons existed in museums throughout the world. Although we will never be able to know the total number of birds killed, the available evidence indicates that

hunting and specimen collecting represented a substantial drain on the population, especially between 1870 and 1920. Annual mortality rates were undoubtedly exceeding annual birth rates by the early 1900's.

RESEARCH AND MANAGEMENT--BEFORE 1954

The year of the discovery of the nesting grounds, 1954, was a major milepost in modern whooping crane history. It provides a logical dividing point between earlier and later research and management efforts. During the period before 1954, there were 4 significant and favorable events concerning the protection of the whooping crane, preservation of important habitats, and illumination of this species' history, behavior, and ecology. Three of them, the Migratory Bird Treaty Act of 1916, establishment of the Aransas National Wildlife Refuge in 1937, and publication of Robert P. Allen's monograph, The Whooping Crane, in 1952, were well known and achieved deserved publicity in their time. The importance of the 4th event, the establishment of Wood Buffalo National Park in the Northwest Territories in December 1922 (Raup 1933), was not realized until 3 decades later, when the nesting grounds were discovered. Had the significance of this been known when Allen (1952) completed his study, in which he stated, "The establishment of the Aransas National Wildlife Refuge in 1937 may well have saved the Whooping Crane," he would certainly have given equal recognition to Wood Buffalo National Park. The following discussion of these 4 events reviews each with respect to its contribution in preserving the species that John Lynch, a USFWS biologist and early patron of Grus americana, affectionately termed the "Great White Bird," in numerous memoranda and reports.

Migratory Bird Treaty Act

The single most significant piece of protective legislation was the Migratory Bird Treaty between the United States and Great Britain (Canada), which was ratified by Congress on 8 December 1916. This Act assured legal protection for migratory birds, including the whooping crane. It provided a basis for cooperation in enacting laws and regulations to allow removal of harvestable surpluses of certain species and to maintain closed seasons on other species that require complete protection.

Wood Buffalo National Park

Wood Buffalo National Park is a vast boreal forest and muskeg area (4,288,542 ha) set aside by the Canadian government in 1922 (Raup 1933) as a preserve and management area for the wood bison (Bison b. athabascæ). The portion of the Park occupied by nesting whooping cranes is located northwest of the intersection of the boundaries of Saskatchewan, Alberta, and the Northwest Territories, except for 1 newly established nesting territory that was recently discovered in extreme northern Alberta (Kuyt 1978b).

After the discovery of nesting whooping cranes within the Park, restrictions regarding entry were made more stringent. The Park administration imposed and enforced stringent regulations on all human activity in the northern part of the Park to assure minimum disturbance during the breeding season. Low-level aircraft operation was prohibited during the breeding season, and fire watches and control were increased. Annual production surveys, which were initiated in 1954, have been continued and intensified. Plans to build a railroad through the Park, and other proposals in potential conflict with whooping crane welfare, have been defeated.

Aransas National Wildlife Refuge

The Aransas National Wildlife Refuge was established in 1937 to protect the whooping crane and other wildlife of coastal Texas (Stevenson and Griffith 1946, Howard 1954). The refuge includes 22,148 ha of the Blackjack Peninsula and adjacent properties and provides essential wintering habitat for the whooping crane. For additional protection, 236 ha of adjoining wetlands, known as the Proclamation Boundary, have been closed to hunting.

The refuge maintains as much as 324 ha of grassland for cranes, waterfowl, and other wildlife. Mowing, prescribed burning, and grazing by livestock are used to reduce excess vegetation and to maintain these grassland areas. Human visitation is carefully controlled, and other potentially conflicting uses of the refuge, such as oil drilling and associated activities, are suspended during the time that whooping cranes are present. In the absence of disturbance, the birds are able to select habitats and establish annual patterns of use on these protected areas. The refuge staff provides protection to the resident whooping cranes and determines their continuing status by frequent patrol and periodic censusing from fall arrival through spring departure.

The Whooping Crane Monograph

Many questions regarding the life history and ecology of the whooping crane remained unanswered. The U.S. Fish and Wildlife Service (then the U.S. Biological Survey) and the National Audubon Society attempted to remedy this situation by setting up the Cooperative Whooping Crane Project. The goal of this project was to secure species survival and population growth through increased protection and sound management. Initial assembly of available information and field investigations began in 1945 and 1946. Late in 1946, Robert P. Allen became the principal investigator for 39 months; his studies culminated in the principal authoritative monograph on the whooping crane published by the National Audubon Society in 1952.

The many individuals and organizations who contributed to the success of this project deserve the gratitude of conservationists for their important contributions to the preservation of this species. This work clearly achieved its ambitious objective and established a sound foundation for subsequent research and management. The value of this publication is indicated by the fact that during the 14 years following the establishment of the Aransas Refuge, the migratory population had a net increase of only 3 birds, from 18 to 21; however, over the next 14 years the population more than doubled, reaching 50. How much of this increased number could be attributed to the tireless efforts of Bob Allen will never be known. The interest of many private citizens and organizations, the dedicated efforts of Federal, state, and provincial personnel in the United States and Canada, the awakened concern of people along the migration route, and newspaper accounts alerting hunters to avoid mistaken shots were all undoubtedly important. The continued survival of the whooping crane, however, attests to the success of these combined efforts.

RESEARCH AND MANAGEMENT--AFTER 1954

Discovery of the nesting grounds in Wood Buffalo National Park, Northwest Territories, Canada, occurred through a chance observation of a whooping crane family by forestry personnel returning by helicopter from a fire on 30 June 1954. The sighting, subsequently

verified by Dr. William A. Fuller of the Canadian Wildlife Service (Allen 1956), stimulated a renewed attempt to save this species from extinction.

Breeding Grounds Research and Management

The discovery of the breeding grounds prompted publication by Allen (1956) of a supplement to his monograph entitled "A Report on the Whooping Crane's Northern Breeding Grounds." This report chronicles the 10 years of exhausting but unsuccessful searching for the nesting area, and provides vivid and valuable descriptions of the frustrating attempts to reach the area by boat and by foot after its discovery. The isolation and impassable terrain of this area still provide the nesting population with important freedom from human disturbance.

The Canadian Wildlife Service reacted to the discovery of the breeding grounds by initiating periodic aerial surveys to document events on the nesting area. Novakowski (1966) provided new insight regarding the use of specific nest site locations by resident pairs year after year. This report also included information on the timing of spring arrivals, the details of nest construction, the availability of food resources, and other aspects of breeding biology.

Between 1954 and 1966, only that portion of Wood Buffalo National Park immediately surrounding the Sass River was surveyed regularly. In 1967, the search area was expanded to include similar habitat in the Klewi River drainage because additional undetected breeding pairs were indicated by the Aransas winter counts and because active nesting territories were located there previously in 1958 and 1963. Additional nesting territories were subsequently located near the Klewi River that year, the Nyarling River in 1970, and the Little Buffalo River in 1977 (Kuyt 1976a, 1978b). During the past 13 years, the whooping crane population has increased from 48 to 78 birds, and the number of known nesting pairs has increased from 9 to 19.

In cooperation with the U.S. Fish and Wildlife Service, the Canadian Wildlife Service has captured and marked pre-fledged young each year since 1977, using techniques and colored leg bands previously tested on cross-fostered whooping cranes in the experimental Grays Lake population. This program is already providing essential information about whooping crane breeding biology, population ecology, behavior, and movements needed for developing and implementing sound management policies (Kuyt 1978a, b; USDI 1980).

Fire patrol and suppression, periodic censusing, prohibition of public access into and low-flying aircraft over the nesting area, and prevention of economic exploitation of the area by various commercial interests remain the 4 most important management functions performed in Wood Buffalo National Park each year. Obviously, little control can be exerted over the weather, predation, water levels, or vegetation growth, and consequently nesting success is governed primarily by the inherent conditions of the breeding pairs and the environment. Most active management is directed toward benefiting the bison, for which the park is named.

Wintering Grounds Research and Management

Despite Allen's (1952) intensive studies on the wintering grounds during the 1940's, and subsequent research on foraging and food organisms by Bill Van Tries and Gordon Folzenlogen in 1965 and 1966, many questions regarding the wintering ecology of the

whooping crane remained unanswered and needed clarification. Thus, the National Audubon Society, in cooperation with the U.S. Fish and Wildlife Service, in 1970 assigned one of their biologists, David R. Blankinship, to conduct research on wintering whooping cranes at and near the Aransas Refuge. This study was intended to update and expand information, to evaluate existing and potential management programs, and to monitor and evaluate potential hazards to the cranes and their winter habitat. Although much of this research is still being conducted, preliminary results on territoriality, adult-young relationships, feeding ecology, and other wintering behavior have been published (Blankinship 1976, Forrester et al. 1978).

During 1972 and 1973, Texas A&M University researchers studied the environmental effects of oyster shell dredging in areas next to the Aransas Refuge. Although adverse effects seem minimal, dredging has been halted in the bays occupied by wintering whooping cranes (Blankinship 1976).

The management of Aransas National Wildlife Refuge is a sizeable and complex operation (Johnson 1976), and various programs have been initiated since 1954. Two 40.5-ha fenced enclosures built between 1964 and 1968 have been planted annually with various cereal and root crops. Although whooping cranes occasionally use these enclosures, most of the food crops are consumed in early winter by sandhill cranes and Canada geese (Shields and Benham 1969). Another change, the diking of a 28-ha impoundment with a high-volume, low-lift pump, brings large quantities of saline water and marine life into the basin; exit of live food items is prevented by screens at spillway outlets.

Although the impoundment attracted waterfowl and wading birds, only limited use by whooping cranes was observed, and consequently the operation was discontinued. Both the fenced cropland and the marine impoundment may become important in the future, however, if natural food supplies are low, or if the cranes must be attracted away from the tidal flats following a chemical or oil spill. Whooping cranes are readily attracted to sites baited with grain, and large stores of grain are maintained at the refuge in case baiting becomes necessary in an emergency. Routine feeding has generally been avoided, however, due to the increased potential for disease transmission.

The refuge staff maintains open grassland areas, which are attractive to whooping cranes, by various brush-control practices, including grazing, mechanical cutting, and controlled burning. Patrolling to prevent human disturbance, periodic censusing to determine status, careful monitoring of petroleum and grazing operations, and maintaining public information contacts are additional management practices intended to enhance the safety of the wintering population.

The most accurate counts of the Wood Buffalo-Aransas population are obtained on their wintering grounds. During each weekly census since 1950-51, the specific location of each sighting has been recorded (Labuda and Butts 1979). As the whooping crane population increases, this and other research information will allow evaluation of current land management practices and will suggest whether additional land acquisition or other policy adjustments are warranted.

Captive Propagation at Aransas Refuge and Zoos

Before the research carried out at Patuxent (described below) successful attempts to propagate whooping cranes had involved only 3 birds--2 females, named

Josephine and Rosie, and a male, named Crip. Josephine was the last survivor of the sedentary, southwestern Louisiana population. Crip and Rosie were from the migratory population, and both were flightless due to injuries obtained in the wild (McNulty 1966, Maroldo 1980).

Crip and Josephine were transferred to the Audubon Park Zoo in New Orleans after several unsuccessful nesting attempts at Aransas. Between 1955 and 1965 Josephine produced 52 eggs at the Audubon Park Zoo. Although 4 male offspring were successfully reared to adulthood (Maroldo 1980), none survive at the present time.

Following Josephine's death on 3 September 1965, Crip and Rosie were paired at the Audubon Park Zoo; however, following an unsuccessful nesting attempt in 1966, they were moved to the San Antonio Zoo in Texas. Although Rosie produced a number of eggs before her death in 1971, only 1 chick, a female named Tex, was successfully raised. This bird, after being hand-reared for 3½ weeks by the Zoo Director, Fred Stark, was transferred to Maryland to become part of the Patuxent flock. Tex was subsequently loaned to the International Crane Foundation in Baraboo, Wisconsin, to join a male (Georgette, renamed Tony) on loan from the Audubon Park Zoo. The International Crane Foundation successfully negotiated the loan of a 2nd male (George, renamed Angus) from Audubon Park Zoo in 1977, and both males were used as semen donors for Tex. Although the badly imprinted Tex laid a single egg in both 1978 and 1979, no chick was successfully hatched. Angus died in 1978 and Tony died in 1979; consequently, in 1980 another captive male from Patuxent was placed on loan to the International Crane Foundation in the hope of obtaining young from Tex.

Between 1971 and 1976, Crip remained unpaired at the San Antonio Zoo. In 1976, a female named Ektu that was hatched at Patuxent in 1967 was transferred to San Antonio for pairing. Ektu produced a single fertile egg in 1978, but it did not hatch. Ektu laid 8 eggs during the 1977 breeding season, and 1 chick, Criptu, was successfully reared. Crip's unexpected death in March 1979 left Ektu unpaired; consequently she and Criptu were transferred to Patuxent, and another pair of adult whooping cranes was loaned to the San Antonio Zoo. Ektu is now paired to a male in the Patuxent flock; unfortunately, Criptu, a female, died shortly after she was shipped to Patuxent.

Whooping Crane Advisory Group

The slow growth of the whooping crane population indicated that conventional management procedures might be insufficient to prevent extinction. Lynch (1956) proposed a captive propagation and release program that would involve the annual removal of a number of young from the Wood Buffalo-Aransas population. These birds would serve as a nucleus of breeders, producing stock to bolster the existing wild flock. This proposal was strongly opposed by several conservation organizations. In 1956, the acting director of the then Bureau of Sport Fisheries and Wildlife, Daniel F. Janzen, called a meeting of representatives of diverse groups for an airing of all viewpoints.

No consensus could be reached on a plan of action, and a pronounced polarity of opinion regarding the merits of captive propagation was evident at the meeting. Janzen subsequently appointed an *ad hoc* committee known as the "Whooping Crane Advisory Group," which included about a dozen representatives of various conservation agencies. The purpose of this group

was to identify existing problems and offer advice to the Bureau.

Sensing the polarity of opinions regarding the merits of captive propagation, Erickson (1961) analyzed the Aransas winter population counts from 1938-1960 and prepared an administrative report entitled "Production and Survival of the Whooping Crane." This analysis revealed 3 important characteristics of the wild population, later confirmed by Novakowski (1966): (1) principal production was apparently derived from a fairly stable cohort of long-lived adults; (2) among birds returning to Canada, mortality was highest in the subadult cohort; and (3) because subadult mortality was apparently limiting recruitment into the breeding population, the population would remain insecure until this mortality was reduced. Based on these findings, Erickson reiterated Lynch's proposal to bolster the wild population through captive propagation and the release of captive-produced stock. However, he cautioned that before stock is obtained from the wild, safe and effective procedures should be developed using sandhill cranes as research surrogates. This proposal received almost unanimous support from the Whooping Crane Advisory Group.

Crane Research and Propagation at Patuxent Wildlife Research Center

Experimentation with sandhill cranes began in 1961 with the concurrence of the Whooping Crane Advisory Group. Immature lesser (*G. c. canadensis*) and greater sandhill cranes were captured on the wintering grounds in 1961 and 1962, respectively; and greater sandhill crane eggs and downy chicks were collected in southeastern Oregon in 1962. These initial studies indicated that egg collecting was the safest and most convenient method of obtaining and transporting wild stock, and therefore only eggs were taken from the wild in subsequent years. Sandhill crane eggs were collected at Malheur National Wildlife Refuge in Oregon and Grays Lake National Wildlife Refuge in Idaho (*tabida*), several locations in peninsular Florida (*pratensis*), and Jackson County, Mississippi (*pulla*). Egg-taking procedures and propagation methods were tested and refined annually.

The experimental flock was initially quartered in temporary facilities at Monte Vista National Wildlife Refuge in Colorado. However, in 1966, Senator Karl E. Mundt sponsored a supplemental appropriation for establishment of the Endangered Wildlife Refuge Program and the development of permanent facilities at the Patuxent Wildlife Research Center in Laurel, Maryland. The advantages of this location, organizational arrangement of this program, and species receiving initial attention have been discussed in detail (Erickson 1968). The captive flock was transferred from Colorado to Maryland in the spring of 1966.

Egg-taking experiments indicated that nest desertion was negligible when 1 egg was removed from 2-egg clutches and population productivity was relatively unaffected. It had previously been noted that cranes normally lay 2 eggs, but nesting pairs rarely fledge 2 chicks. Observations by Novakowski (1966) confirmed that whooping cranes generally follow this pattern, so it appeared that 1 egg could be removed from each 2-egg clutch with the same favorable results experienced with sandhill cranes.

These findings were communicated to the Whooping Crane Advisory Group, which concurred in the decision by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service to obtain eggs from wild nests in

Wood Buffalo National Park in 1967. The egg gathering was repeated in 1968, 1969, 1971, and 1974 to further augment the Patuxent population, and annually since 1975 to provide eggs for the Grays Lake crossfostering experiment (see below).

Fifty eggs were taken from the wild between 1967 and 1974 (Table 2). Chicks raised from these eggs formed the nucleus of the captive flock currently being maintained at Patuxent. The egg collections and subsequent propagation efforts have been described previously (Erickson 1975, 1976, Kuyt 1976a, Kepler 1976, 1978, Carpenter 1979).

As noted by Erickson (1976) and Kuyt (1976a), these egg removals have not adversely affected the productivity of the wild population. The Wood Buffalo-Aranzas population has in fact increased from 48 to 78 individuals between 1967 and 1980, and the number of breeding pairs has increased from 9 to 19.

The captive whooping crane flock at Patuxent currently numbers 22 individuals of 9 year classes: 1964, 1 (CANUS); 1967, 2; 1968, 3; 1969, 2; 1971, 2; 1974, 3; 1976, 1; 1977, 2; 1978, 3; and 1979, 3. Other birds, 3 derived from wild eggs, are currently on loan to the International Crane Foundation (2) and the San Antonio Zoo (2).

Propagation research at Patuxent has now reached the refinement, as opposed to the developmental, stage. Although most propagation techniques developed for sandhill cranes can be applied directly to whooping cranes, the latter have required certain procedural modifications. Whooping cranes have generally proved to be more difficult to raise than sandhills, and most mortality has occurred within 1 month of hatching, as a result of bacterial infections, coccidiosis, and leg disorders resulting from rapid growth (Kepler 1978). Whooping cranes appear to gain weight more rapidly than sandhill cranes and, unless food intake is restricted, growth exceeds the capacity of their legs to support their increased body weight. Problems immediately begin to develop with articulation at the knee, hock, and toe joints, the bird assumes a "knock-kneed" appearance, and the toes begin to flex inward. This ailment has been successfully treated by limiting the daily food and energy intake to an amount that will avoid excessive weight gain, or by increasing the chick's activity level so that excess energy is spent in exercise, or both. Foster in-

ubation, hatching, and rearing of whooping crane chicks by sandhill cranes has provided a useful means of meeting exercise requirements because chicks follow their parents through the tall grass in the enclosures in search of insects and other supplementary food items. None of the foster-parent-reared whooping cranes have developed leg or toe problems.

Eggs were first produced at Patuxent in 1975, when 1 female laid 3 eggs (Table 3). Since that time several additional females have become productive. Although 1 female produced her 1st eggs when 5 years old, most females have not laid until they were between 7 and 11 years old. Behavioral factors responsible for delaying their initial breeding attempts have been discussed by Kepler (1976, 1978).

Between 1975 and 1980, the captive flock produced 80 eggs (Table 3). Eggs are removed as laid to assure maximum productivity. Because none of our breeding pairs successfully copulate on their own, they are artificially inseminated 3 times per week and immediately after each oviposition during the breeding season.

One of the current objectives of the captive propagation effort at Patuxent is to provide eggs for the Grays Lake cross-fostering experiment. Thirty-eight whooping crane eggs have been transferred from Patuxent to Grays Lake: 2 in 1976, 14 in 1977, 15 in 1978, 5 in 1979, and 2 in 1980 (Table 3).

Original attempts to artificially incubate whooping crane eggs suggested problems with less than optimum incubation regimes. Results obtained in 1978 supported this conclusion because (1) hatchability of the 8 eggs retained at Patuxent and incubated under sandhill cranes was high (88%); (2) only 5 of 11 eggs receiving artificial incubation before transfer hatched at Grays Lake; and (3) examination of the 6 fertile eggs that did not hatch at Grays Lake revealed 4 late-dead and 2 early-dead embryos. As a result, in both 1979 and 1980, all whooping crane eggs were incubated under Sandhill cranes before transfer, and only eggs that contained viable embryos (as determined by flotation) were shipped. Hatchability and survivorship in both years equalled that observed in eggs and chicks derived from the Wood Buffalo population (Table 4).

The Grays Lake Cross-fostering Experiment

Security of many wildlife species lies in their

Table 2. Whooping crane eggs transferred to the Patuxent Wildlife Research Center from Wood Buffalo National Park 1967-1974 (adapted from Erickson 1975).

Year	No. eggs		Chicks hatched		Reared to 6 months		
	Removed	Remaining	Patuxent	Canada	Patuxent	Canada	Total
1967	6	11	5	10	4	9	13
1968	10	10	9	11 ^a	7	6	13
1969	10	12	7	11	5	8	13
1971	11	13	7	11	3	5	8
1974	13	15	9	15	4	2	6
Total	50	61	30	58	23	30	53

^aIncludes 1 chick that hatched in Canada and was taken to Patuxent.

dispersal and occupation of a variety of locations. Thus, establishment of additional, self-sustaining whooping crane populations should divide the risk and increase the prospects for survival. Several approaches for establishing additional whooping crane populations have been suggested, but the only method tested thus far is cross-fostering--a technique proposed over 2 decades ago by Fred Bard, former Director of the Saskatchewan Museum of Natural History.

Since 1975, whooping crane eggs from wild nests in Wood Buffalo National Park and from the captive flock at the Patuxent Wildlife Research Center have been transferred to Grays Lake National Wildlife Refuge in southeastern Idaho, and substituted in the nests of greater sandhill cranes. The foster-parent sandhills are subsequently allowed to incubate, hatch, and rear the young whooping cranes. Information on the Grays Lake sandhill crane population and details of this cross-fostering experiment have been discussed previously (Drewien 1973, Drewien and Bizeau 1974, 1978, Drewien and Kuyt 1979, USDI 1980).

Many of the initial questions raised by this technique (i.e., Will proper migratory traditions be established? Will the cross-fostered whoopers adapt to the obvious habitat and dietary differences?) have now been answered, and field observations indicate that behavioral incompatibilities between the 2 species will prevent mixed species pairing and subsequent hybridization. The experimental population currently numbers between 17 and 20 individuals (Table 4). They migrate between summering areas at or in the vicinity of Grays Lake and wintering areas in the Rio Grande Valley of New Mexico and northern Mexico.

Although the prospect for reestablishing a 2nd population of whooping cranes in North America appears

reasonably good, the rate of increase in the Idaho-New Mexico population has been low due to (1) adverse weather conditions at the time of hatching and chick rearing, (2) coyote predation on chicks before fledging, and (3) the restricted number of eggs available for transplanting. Together, these factors have resulted in a relatively small population with few individuals in each year class (Table 4). Three sexually mature males currently maintain and defend territories at Grays Lake during the breeding season but unfortunately remain unpaired. The absence of successful pairing and reproduction in the population at this time appears to be due to the absence of females in the older age cohorts (R. C. Drewien, pers. comm.).

Since the initiation of the Grays Lake experiment it has become apparent that egg production at Patuxent begins well in advance of nesting at Grays Lake. The number of eggs that can be transferred from Patuxent to Grays Lake in any given year, therefore, depends upon the phenological differences between the 2 locations. Whooping crane eggs that are laid too early in the season for transfer to Grays Lake are now being incubated and hatched, and the chicks are subsequently reared, by captive pairs of sandhill cranes. These foster-parent-reared whooping cranes could be used either to augment the Grays Lake flock or to establish additional populations at other potential breeding areas. Direct releases of parent-reared whooping cranes have not been conducted thus far, however, because it is feared that, unlike cross-fostered individuals, which accompany their foster parents on their first migration, these "naive" birds might migrate through or winter in undesirable locations where conflicts could occur with waterfowl hunting. Captive, parent-reared sandhill cranes are currently being released in both migratory and nonmigratory populations, and these studies will provide valuable information

Table 3. Summary of eggs produced by the captive flock at Patuxent Wildlife Research Center.

Year	No. of laying females	Total no. eggs	Eggs retained at Patuxent			Eggs transferred to Grays Lake				
			No.	No. fertile ^a	No. hatched	No. surviving	No.	No. fertile ^b	No. hatched	No. surviving
1975 ^c	1	3	3	2	1	0	0	0	0	0
1976 ^c	2	5	3	1	1	1	2	?	0	0
1977 ^c	4	22	8	4	33	2	14	?	5	0
1978 ^d	3	23	8	8	7	3	15	11	5	0
1979 ^e	3	21	16	11	8	3	5	4	4	2
1980 ^e	2	6	4	1	0	0	2	2	2	1

^aFertility is determined for unhatched eggs by examination after full-term incubation. Eggs containing no detectable embryo are listed as infertile, but may have involved early embryo death; consequently, fertility estimates are minimum estimates.

^bEggs transferred to Grays Lake in 1976 and 1977 were not opened after full-term incubation. In 1977, among the 14 eggs transferred, 3 were deserted after a snowstorm, 1 was destroyed by a predator, and 5 were either infertile or addled.

^cAll eggs artificially incubated and chicks at PWRC were hand-reared.

^dAll eggs retained were incubated under sandhill cranes; all eggs transferred to Grays Lake were artificially incubated before transfer.

^eAll eggs incubated under sandhill cranes.

Table 4. Summary of Grays Lake transplant experiment.

Year	Origin of eggs	No. eggs transplanted	No. eggs hatched	No. chicks fledged	Current no. surviving
1975	Canada	14 ^a	9	6	2-3
1976	Canada	15 ^b	11	4	2
	Patuxent	2	0	0	0
1977	Canada	16	15	4	1
	Patuxent	14 ^c	5	0	0
1978	Canada	13	9	3	2
	Patuxent	15 ^d	5	0	0
1979 ^e	Canada	19	12	6	4-5
	Patuxent	5	4	2	2
1980 ^e	Canada	13	10	4	3-4
	Patuxent	2	2	1	1

^aTwo of 14 eggs lost to predators.

^bFour of 15 eggs lost to predators.

^cThree eggs deserted after snowstorm, 1 egg lost to predator.

^dExamination of 10 eggs that did not hatch revealed 4 were infertile, 2 contained early-dead embryos, and 4 were late-dead embryos.

^ePoor hatchability of Patuxent eggs 1976-1978 was due largely to egg infertility and artificial insemination. In 1979 and 1980 only eggs containing viable embryos (as determined by flotation) were transferred and all eggs were incubated "naturally" under sandhill cranes at Patuxent before their transfer.

for designing future reintroduction attempts with whooping cranes.

Migration Monitoring Program

Relatively little is known about the ecology and requirements of migrating whooping cranes. Although a number of sightings have been reported and compiled over the years (Allen 1952, Sutton 1967, Walkinshaw 1973, Archibald et al. 1976), relatively few sightings are verified each year. To protect migrating whooping cranes from disease outbreaks and other hazards and to compile information on the characteristics and location of stopover sites, the Fish and Wildlife Service initiated a migration-monitoring program in 1977. This "Flight Tracking Project" alerts key personnel about reported sightings in the flyway, so that they can be verified and the birds kept under protective surveillance. To increase the collection of information, this monitoring program is now being coordinated with the reporting networks of the National Audubon Society, the Canadian Wildlife Service, and the states along the flyway.

Whooping Crane Recovery Plan

The future direction of research and management efforts on behalf of the whooping crane are the subject of continuing deliberations by the Whooping Crane Recovery Team. This group consists of an informed group of 7 members and additional consultants and advisors representing federal, state, and private conservation agencies and organizations. The Recovery Team is directed to operate in the best interests of the whooping crane, independent of political, economic, or other nonbiological concerns.

The Whooping Crane Recovery Plan, which was developed by the Recovery Team and approved by the Director of the Fish and Wildlife Service on 23 January 1980, describes actions deemed necessary to restore this species to safer numbers. The principal objective of the Recovery Plan is to improve the status of the whooping crane from endangered to threatened. As currently stated, the minimum requirements for this change in status include (1) increasing the Wood Buffalo-Aransas population to at least 40 nesting pairs, and (2) establishing at least 2 additional, disjunct populations of at least 20 nesting pairs each. To achieve these goals, the Recovery Plan outlines a variety of management and research objectives, including habitat management, captive propagation, and the development of reintroduction-release procedures, reduction of current mortality rates, and improvement of public information. Each of these objectives is discussed more fully below.

Habitat Management.--Nine refuges and migratory stopover areas used by the Wood Buffalo-Aransas and Idaho-New Mexico populations have been designated as critical habitat for the whooping crane (i.e., Aransas NWR (Texas), Salt Plains NWR (Oklahoma), Quivira NWR and Cheyenne Bottoms WMA (Kansas), the Platte River bottom (Nebraska), Grays Lake NWR (Idaho), Monte Vista NWR and Alamosa NWR (Colorado), and Bosque del Apache NWR (New Mexico)] (Federal Register 15 May 1978). These areas are considered critical to the survival and recovery of the whooping crane. Although the Recovery Plan recommends that habitat management and research should 1st be applied to these areas, it recognizes the need to identify and protect additional areas along the migration route. Because little is known about whooping crane migration ecology, the

Recovery Plan recommends additional research aimed at determining the location and characteristics of migration stopover sites.

Captive Propagation and Reintroduction Techniques

--The Recovery Plan calls for continuation of whooping crane captive propagation efforts. Eggs and young produced in captivity will be used to develop reintroduction and release methods for establishing more migratory or nonmigratory populations or both. Along with the cross-fostering experiment at Grays Lake, Idaho, experimental releases of sandhill cranes are being made to evaluate various pre- and post-release procedures. The Recovery Team is preparing a list of potential whooping crane release sites based on their suitability and the biological needs of the species. Sites for additional whooping crane populations will be chosen in consultation with private conservation organizations, and federal, state, and provincial agencies of the United States and Canadian governments.

Reduce Mortality.--As previously mentioned, relatively little is known about whooping crane mortality. Although hatchability is generally high, chick survivability is seriously low in some years. The factors behind these losses of preledged young can be only conjectured until more intensive studies are carried out. The heaviest losses among adult-plumaged whooping cranes seem to involve primarily nonbreeders. Furthermore, because there have been very few reported losses in migration and on the wintering grounds, it appears that most mortality occurs during the summer months (Erickson 1976). During the past 42 years, about 160 whooping cranes are known to have disappeared between their departure from Aransas in the spring and their reappearance in the fall. The slow growth in the Wood Buffalo-Aransas population during recent decades seems to have resulted primarily from a decline in the mortality rate (Miller et al. 1974); consequently, if losses of adult-plumaged birds can be prevented or reduced, population growth should be substantially accelerated. The Recovery Plan places a high priority on identifying the causes of mortality and implementing remedial actions.

Improvement of Public Information.--There can be little doubt that the public information programs by organizations such as the Whooping Crane Conservation Association (Scott 1976), the National Audubon Society, and the International Crane Foundation have benefited the whooping crane. The Recovery Team strongly believes that the preservation and eventual recovery of the whooping crane will require the interest and concern of an informed public. With this objective, the Recovery Plan recommends a continuation and expansion of public information and education programs.

Although the status of the whooping crane has improved considerably over the past 40 years, restoration will obviously entail long-term commitment and cooperation of private individuals and organizations, and public agencies in the United States and Canada. Much remains to be learned about Grus americana, and the Recovery Plan will be appropriately amended as new information becomes available.

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POPULATION STATUS, NEST SITE FIDELITY, AND BREEDING HABITAT OF WHOOPING CRANES

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Abstract: Aerial surveys of the whooping crane (*Grus americana*) summer range 1966-1979 indicate a slow increase in the breeding population from about 10 pairs in 1968 to 19 pairs in 1979. Since 1975 the nonbreeding segment of the population has increased markedly, no doubt partly due to a succession of 3 years of excellent production of young and simultaneous below-average mortality of older birds. The proportion of known breeding birds in 1979 was 50% and recruitment from the large nonbreeding segment into the breeding population will probably occur in the next few years.

Breeding pairs' successive nest sites were close to each other and the mean size of composite nesting areas was 7.5 km², although more than 70% of these areas were less than 5 km². Whooping crane nests from adjoining pairs are usually more than 1 km apart. The most common nest material is roundstem bulrush (*Scirpus validus*); cattail (*Typha latifolia*) and sedge (*Carex* sp.) are less commonly used. There is no evidence that nests are reused. The breeding habitat is described; many other similar areas can be found in the vicinity of the breeding range but whooping cranes rarely occur there, presumably because there are not enough birds to occupy the vacant space.

The whooping crane is North America's most widely publicized bird. The species, listed as endangered, is making a slow comeback from a low of 15 wild birds in 1941 to the present 91 birds. The population migrates annually between the breeding range in Canada's Wood Buffalo National Park (WBNP) and the winter range in Aransas National Wildlife Refuge (ANWR) in Texas, USA. The Migratory Bird Treaty Act of 1916 requires Canada and the United States to protect whooping cranes and these obligations have resulted in a number of cooperative management programs.

Information on location, magnitude, and productivity of the breeding population is obtained from regular Canadian Wildlife Service (CWS) aerial surveys in WBNP (Fig. 1). Aerial census flights are carried out regularly by the staff of ANWR when the whooping cranes are wintering and the resulting population figures are accurate because all birds habitually winter on ANWR.

POPULATION STATUS

Almost all of the range occupied in summer by breeding and nonbreeding whooping cranes lies in the Northwest Territories (NWT) portion of WBNP. Unlike the situation in ANWR, the total crane population is never accounted for in WBNP because manpower and funding restrictions prevent thorough searches for scattered nonbreeding birds in isolated areas uninhabited by man.

At the present time the NWT-Texas flock numbers 76, the highest on record. There also are 28 whooping cranes in captivity in the USA and 15 wild birds in the Rocky Mountain (foster-parent) population. All but a few of these 43 birds have been raised from WBNP eggs. Since 1967 when 9 nests were found, the breeding population has climbed to 19 pairs in 1979, an increase of less than 1 pair per year. The lowest point in the whooping crane population is generally accepted as having occurred in 1941 when only 15 wild birds were still believed to exist in the NWT-Texas flock. The only other wild population existing at the time, 6 sedentary birds in Louisiana, became extinct in 1949.

Breeding Population

I believe that in 1966 and 1967 all breeding pairs may not have been located because of workers' unfamiliarity with the breeding area. However, recent small

increases appear to be due to new pairs becoming established in nesting areas hitherto uninhabited rather than to any undiscovered existing pairs. In 1970 a new nesting pair was located in the extreme northern portion of the breeding range where in 1977, 1978, and 1979 a second pair nested. A new pair first nested in the extreme southern part of the breeding range in 1977, returning there in 1978 and 1979. One or possibly 2 new pairs nested along the Klewi River in 1979. At the same time we lost at least 1 nesting pair in the Sass area. There has therefore been a slight extension of the known breeding range and a small numerical increase in breeding pairs (Table 1).

In 1973, 1974, and 1975 the combined total of yearlings, subadults, and nonbreeding adults was less than

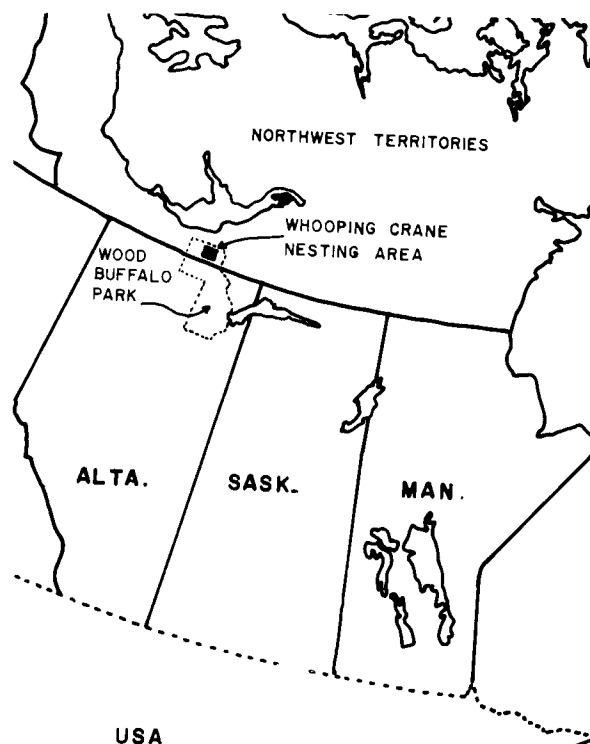


Fig. 1. Location of Wood Buffalo National Park and the whooping crane nesting area.

the corresponding years' known breeding population. This was the result, in part, of poor survival of young during spring and summer of 1973 and 1974. Since 1976, the situation has reversed, with the known nonbreeding population equal to (only in 1979) or less than the nonbreeding population (Table 2). The reversal is partly because of excellent survival of juveniles from 1975 to 1977. During years when surplus eggs were removed from the wild (for transfer to the U.S. Fish and Wildlife Service's Patuxent Wildlife Research Center, Maryland, USA, or to the foster-parent project at Grays Lake National Wildlife Refuge, Idaho; Table 3), survival of chicks from remaining eggs in WBNP was considerably higher than in years when eggs were not collected (Erickson 1976). With recruitment into the breeding population of birds previously in the nonbreeding segment the breeding population is expected to increase beyond the record of 19 pairs in 1979.

Nonbreeding Population

Age of wild whooping cranes at first breeding is not yet known but from observations of captive birds, and from limited observations of wild birds in the Rocky Mountain flock, this age is believed to be upwards of 3 years. In addition to breeding birds, the NWT-Texas flock probably contains sexually immature birds, adult cranes unable to find compatible mates, cranes having lost their mates, and senile birds. Under good field conditions, only the juvenile birds up to 1 year old can be distinguished from "adult" cranes by the presence of cinnamon-colored feathers of the juvenile plumage. None of the other nonbreeding white plumaged birds could be distinguished until 1978, the year after CWS began color-banding juvenile flightless whooping cranes (Kuyt 1978, 1979a). During aerial searches for nesting whooping cranes, I located banded nonbreeding birds in an area between 2 subsections of the breeding range (Kuyt 1979b). Fortunately, the area presently inhabited by nonbreeders is also well within the boundaries of WBNP.

Table 1. Location of whooping crane breeding pairs.

Year	Sass River	Klewi River	Nyarling River	Alberta	Total
1966	5	a	a	a	5
1967	6	3	a	a	9
1968	6	5	a	a	10
1969	5	7	a	a	12
1970	6	8	1	a	15
1971	7	5	1	a	13
1972	8	7	1	a	16
1973	7	6	1	a	14
1974	8	6	1	a	15
1975	8	7	1	a	16
1976	8	7	1	a	16
1977	8	6	2	1	17
1978	5	7	2	1	15
1979	7	9	2	1	19

^aNot surveyed.

Color-banding has also revealed that there has been satisfactory survival of the 3 banded year classes. among the 3 cohorts, 7 (1977), 5 (1978), and 6 (1979) are still alive (D. Blankinship, pers. comm.). One bird banded in 1979 failed to arrive at Aransas but a second, unbanded, juvenile survives.

NEST SITE FIDELITY

Before 1966, monitoring of the whooping crane population on summer range was restricted almost exclusively to aerial surveys over the Sass River area. Since 1966, aerial coverage of the Sass River area has been intensified and extended to the Klewi River drainage adjoining the Sass River. In 1970 a small portion of the marshes near the Nyarling River was surveyed for the first time along with areas between the Nyarling and Klewi Rivers. Small areas south of the Sass area came under survey in about 1974.

During early surveys it became obvious that whooping crane nest sites in successive years were close together. Whooping cranes are long-lived birds and, if homing instincts and nest site fidelity are as well established in whooping cranes as in other species, the nest of a particular pair of cranes should be close to its previous year's nest.

Since 1970-1971 all nest sites have been plotted on large-scale aerial photographs (2.5 cm = 300 m) and nests found earlier (originally plotted on older 1 inch = 1 mile air photos) transposed to the new air photos. I have plotted 192 whooping crane nests since 1966 and at no time have cranes used the same nest in consecutive years. New nests are built each year, usually close to the previous site and often on the same marsh.

After I had accumulated several years data, circles were drawn on the map encompassing clumped nest sites believed to be consecutive nests of particular pairs. In successive years a high proportion of nests have fallen within these circles (Figs. 2 and 3). A territory may best be defined as any defended area and the term implies hostility and site tenacity. Limited information provided by a ground crew filming whooping cranes in 1974 indicated frequent calling between members of 3 neighboring breeding pairs (R. Mackay, pers. comm.).

During aerial surveys I have noted that resident breeding birds attacked and chased off intruding single or paired whooping cranes. Territorial defense occurs, but because breeding whooping cranes need to establish dominance relations with only a few other whoopers, lightly populated breeding range and nesting areas of long-lived cranes are used for many years, extremely vigorous territorial encounters between neighboring breeding pairs are unlikely.

The circles on the maps encompassing clumped nests probably include territories used by a single pair in a succession of years and are referred to as composite nesting areas (CNA).

None of the breeding birds can be positively identified individually. I cannot, therefore, be certain that a breeding pair seen in a territory is the 1 observed there the year before, but some supportive evidence is available. For example I have been able to determine that 1 of the adults in CNA Sass-1 for several years had an apparent neck growth (photographed at close range by the National Film Board in 1974) and pairs using CNA Sass-3 and Klewi-7 have an apparent

Table 2. Composition NWT-Texas whooping crane population.

Year	Number of known breeding birds	Total population ^a	Juveniles ^a	Maximum no. of nonbreeders
1966	10	43	5	b
1967	18	48	9	b
1968	20	50	6	30
1969	24	56	8	32
1970	30	57	6	27
1971	26	59	5	33
1972	32	51	5	19
1973	28	48	1	20
1974	30	49	2	19
1975	32	57	8	25
1976	32	69	12	37
1977	34	70	10	36
1978	30	74	6	44
1979	38	76	6	38

^aData from Refuge Manager, Aransas National Wildlife Refuge, Texas.

^bDate probably not complete.

Table 3. Disposition of whooping crane eggs collected 1967-1979.

Year	Estimated no. eggs produced	Eggs available	Eggs left	Eggs collected and disposition
1966	9-10	4-5	9-10	0
1967	17	6	11	6 Patuxent
1968	20	10	10	10 Patuxent
1969	22	10	12	10 Patuxent
1970	27-29	12-14	27-29	0
1971	24	11	13	11 Patuxent
1972	26-31	10	26-31	0
1973	26	12	26	0
1974	29	13	16	13 Patuxent
1975	31	14	15 ^a	14 Grays Lake
1976	32	16	16	15 ^b Grays Lake
1977	35	16	16 ^c	16 Grays Lake
1978	28	13	14 ^d	13 Grays Lake
1979	39	19	18 ^a	19 Grays Lake
Total	365-373		229-237	50 Patuxent 77 Grays Lake

^aBoth eggs in 1 nest were found destroyed at time of egg pickup.

^bSixteen eggs collected from nests (1 egg was added) and only 15 eggs were shipped.

^cNest 15-77, containing 3 eggs, was found destroyed before egg pickup.

^dNest 15-78, with 1 egg, was abandoned before egg pickup.

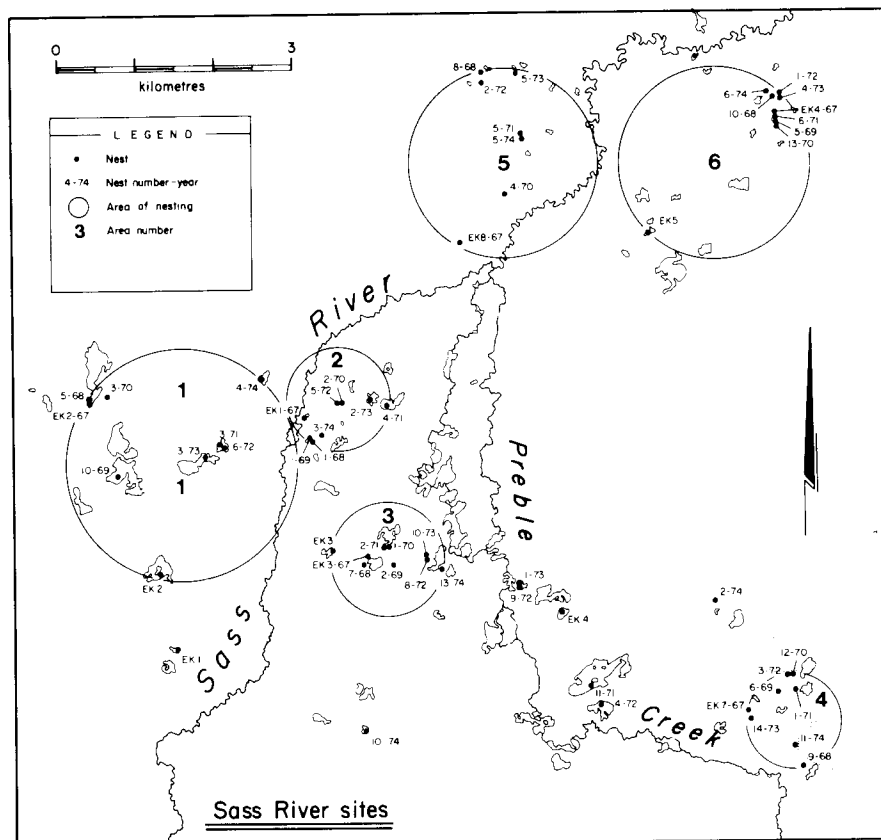


Fig. 2. Sass River whooping crane nesting areas, 1966-1979.

chronic inability to produce viable eggs. Thus, the composite nesting areas are of sufficient discreteness to give us confidence that each is used by the same pair in successive years.

Although whooping cranes are long-lived birds, eventually their reproductive life comes to an end and remaining partners may find a new mate. It is likely that the territorial bond is strong enough to cause the return of a former resident with its new mate to the old territory. Territories then may be reused many years and territories only become vacant if both adults disappear simultaneously.

After the eggs have hatched the chicks may use the nest for up to 3 days. Usually the family group moves gradually greater distances from the nest site using parts of its territory, not returning to the nest site but resting or brooding the chick when unfavorable weather or low temperatures are encountered. Movements of family groups are monitored at weekly intervals and locations plotted on air photos. I found that for most of the summer the family group remains within the circle indicating the composite nesting area and during that time the CNA may resemble the home range. Encroachment of 1 family on another's territory occurs rarely and then only when the resident family is on the opposite side of its territory.

Since 1977 we have color-banded juvenile whooping cranes on the breeding range. When the survivors of the banded cohorts become absorbed into the breeding population, and if bands remain visible, detailed information on nest site fidelity, pair bonding, and

many other aspects of whooping crane biology will become available.

DISTRIBUTION OF BREEDING PAIRS

Examination of the CNA's shows that not all areas are used uniformly as nesting sites. Some areas appear to be favored by the nesting pair and others are rarely used. In CNA Sass-1 the western portion of the area was used from 1967-1970. Many of the potential nesting ponds then became dry and since 1971 the central and northeastern portions of the CNA have been used, an area much smaller in size than the circled area.

CNA Sass-2 was not used by breeding cranes in 1978. The juvenile raised there in 1977 was color-banded that year and information from ANWR indicated that 1 of the adults accompanying the banded young died during the family's residence on the winter range. A single crane was seen in the CNA in 1978 and 1 year later a breeding pair was again in the territory.

CNA Sass-5 suffered from drought in late summer and, in 1977 and 1979, the family spent considerable time in the southern part of its territory near the more stable water conditions of the Sass River, and even touching CNA Sass-6, vacant since 1976. Sass-6 was used by a breeding pair each year from 1966-1976. In 1976 both eggs failed to hatch (they contained no identifiable embryo) and no pair has since returned.

The breeding pair in Sass-3 has a long history of unproductivity. Only a single egg was laid in several

years and eggs always failed to hatch due to unknown reasons. Both eggs laid in Sass-3 hatched in 1979 for the first time. Canadian chick 7-79 was killed by a wolf about 7 days before attainment of flight and Idaho chick 7-79 is still alive. Monitoring of the family in WBNP during the summer indicated that the family used the home range determined for the breeding pair usually nesting in CNA Sass-7. It is possible that with Sass-3 not being defended due perhaps to loss of the resident breeding pair, the pair from adjoining CNA Sass-7 was at liberty to nest in Sass-3.

In the Klewi River area, CNA Klewi-7 has a history somewhat similar to that of Sass-3. Nesting was first recorded in 1969 and has been irregular since then. None of the eggs produced in the area between 1969 and 1978 has hatched. In 1976 a nest was abandoned when the single egg disappeared shortly after having been laid. A second nest, apparently a re-nesting, contained 2 eggs, neither of which hatched. In 1977 we

could not locate a nest in the area although a pair of cranes was observed a number of times. The following year an egg was laid in nest 3-78 on or about 4 May but the 2nd egg was not laid until about 8 May (eggs are usually laid a day apart). Neither of the 2 eggs hatched although a postmortem examination revealed embryo development and embryo death before hatching.

In 1979 a pair of whoopers nested 1.5 km southwest of the previous nest site and eggs were laid on about 9 and 12 May. The egg removed to Grays' Lake, Idaho, was destroyed there by a predator but the egg left in the nest in WBNP hatched. The chick, however, disappeared between 26 June and 3 July.

In CNA Klewi-6, three distinct marsh complexes were used. From 1967 to 1969 and in 1976 a large oval-shaped marsh surrounded by forest was used. The marsh had dried up by 1976 with the exception of a small portion in the west. From 1970 to 1972 and in 1978,

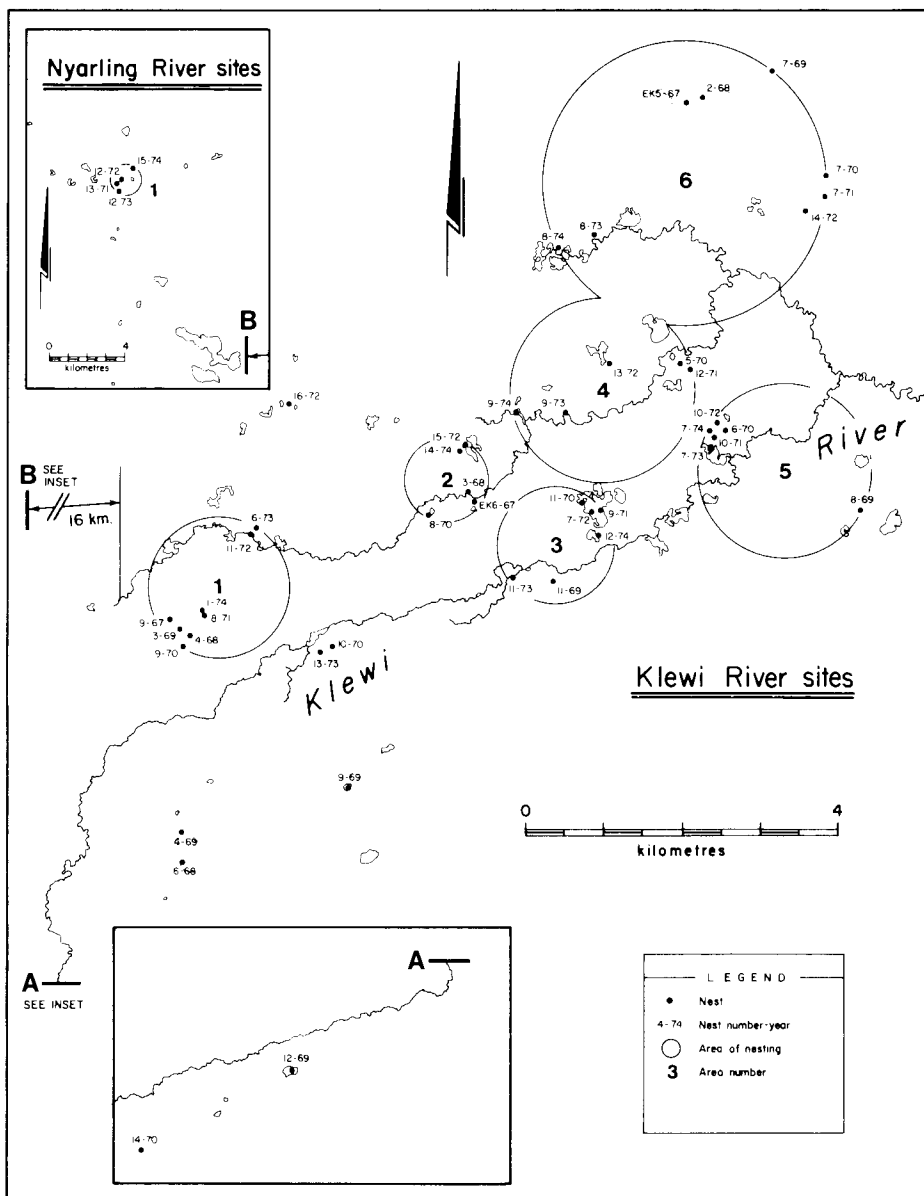


Fig. 3. Klewi and Nyarling Rivers whooping crane nesting areas, 1967-79.

nests were found in the northwest portion of another large marsh complex separated by coniferous forests from the other 2 marshes. Finally from 1973 to 1975, in 1977 and 1979, nest sites were found to the west, near the more stable water conditions of a branch of the Klewi River. Single feeding birds were frequently seen in 1 of 2 marsh complexes not used as nesting marshes in certain years and I think that these were mates of the incubating bird in the 3rd marsh.

Drought has also affected CNA Klewi-5. Since 1969 nests have not been found in the southeast portion and all nests since 1970 have been located near 1 of 2 branches of the Klewi River.

In CNA Klewi-4 there has been a westward shift in the nesting locations selected by the resident pair, perhaps in response to changes in pond water levels or to the encroaching trend of the resident pair in CNA Klewi-5. From 1974 to 1979 the pair in Klewi-4 used a small area near the widening of a creek flowing into the north branch of Klewi River.

In CNA Klewi-1 all but 4 nests were found along the eastern portion of a vast sedge marsh. Most often the cranes select a cattail (*Typha latifolia*) marsh and the nest consists almost entirely of cattail. From 1972 to 1973 and in 1978 and 1979 the birds selected nest sites near the north branch of the Klewi River but the family group spent most of the summer south of that branch and often near former nest sites.

Two nesting areas are known from the Nyarling area. Area 1 had a resident pair from 1971 to 1979. In 1976 the pair nested close to the Nyarling River on a shallow lake which has remained dry or almost dry since 1976. The pair had nested in all other years near the northeast side of the territory in a fairly small area estimated at about 8 km². Area 2, in use only since 1977, is probably the nesting area of a new pair. A new pair was also found nesting in 1977 in the Alberta portion of WBNP and the pair returned in 1978 and 1979 to nest in a small area.

I have been unable to assign some nest sites to any particular CNA. In most situations these nests are scattered along the Sass and Klewi Rivers, usually at

considerable distances from existing CNA's. Klewi nests 17-79 and 19-79 are believed to be those of new or inexperienced pairs because the latter nest was located in an exposed area from which the egg was taken by a black bear (*Ursus americanus*) and a marked juvenile from the former nest wintered with its parents on a section of ANWR not previously used by whooping cranes (D. Blankinship, pers. comm.).

Nesting areas Klewi-1, Klewi-6, and Sass-4 are the most productive areas, 2 eggs being laid in each nest uninterruptedly from 1967 to 1979. Observations of banded birds on winter range in ANWR have shown that all 9 whoopers fledged from these 3 nests, during the last 3 years, are still alive (D. Blankinship, pers. comm.).

From 1966-1979, the nests closest together in any 1 year were 9-78 (CNA Klewi-4) and 13-78 (CNA Klewi-3), about 800 m apart.

SIZE OF BREEDING RANGES

Size of the CNA's varies considerably (Table 4). A more accurate evaluation of these areas, including measurement of breeding territories and home ranges, will be possible when juveniles marked in 1977, 1978, and 1979 enter the breeding population.

The CNA's presently contain large spaces not used for nesting, although most of the area is utilized by breeding pairs or family groups during their daily activity of feeding and resting. Only when juveniles have approached flight stage does the family group sometimes cross the arbitrary borders of the CNA.

Territorial behavior helps to ensure survival of a part of the population (Erickson 1938). There is little evidence that territorial encounters of whooping cranes are anything more than frequent vocalizations between adjoining breeding pairs when incubation has started. Occasional challenging and pursuit of non-breeding interlopers, by a member of a resident breeding pair, may also occur. Frequent territorial flights near nest sites would draw attention of potential predators to the relatively conspicuous incubating crane and such fights would not be entirely

Table 4. Size (km²) of whooping crane composite nesting areas.

Sass River	Klewi River	Nyarling River	Alberta	All areas
#1 7.1	#1 3.3	#1 47.1	Alberta 0.4	
#2 1.9	#2 2.2	#2 22.4		
#3 1.7	#3 2.2			
#4 1.3	#4 4.8			
#5 4.4	#5 5.5			
#6 4.8	#6 11.2			
#7 1.9	#7 4.7			
#8 2.5				
Range				
1.3-7.1	2.2-11.2	22.4-47.1		0.4-47.1
Mean				
3.2	4.8	34.8	0.4	7.2

beneficial to the species. The present low density of nesting whooping cranes is probably responsible for the large breeding territories and extensive areas between adjoining territories where whoopers are rarely seen.

This arrangement undoubtedly is attractive to the long-lived whooping cranes which become closely attached to their breeding terrain and return year after year. Along with the relative quiet of the breeding territory, the cranes also find an adequate food supply and nest material. They become intimately acquainted with feeding areas and escape terrain (Tinbergen 1957). Fidelity to nest sites embodies all of these factors and is certain to enhance survival.

BREEDING HABITAT

The whooping crane breeding range as it is now known, and areas used by nonbreeders, lie near the northern edge of the Boreal Forest Region. Characteristic conifers found in the areas are white spruce (*Picea glauca*), black spruce (*P. mariana*), tamarack (*Larix laricina*), and jack pine (*Pinus banksiana*) with lesser amounts of deciduous broad-leaved species such as white birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*). Within the Boreal Forest Region the whooping crane's summer range is contained in the Hay River Forest Section (Rowe 1972) and lies just west of the limit of the Canadian Shield. Rocky escarpments scattered throughout the area are of Devonian age and are composed of limestone. As a result of glacial action, calcareous material constitutes a high proportion of the surface drift with resultant leaching of the lime-containing soils. Sinkholes are of fairly common occurrence in the region. The pH of water in nesting and feeding ponds was found to be from 7.6 to 8.3 (Novakowski 1966).

The areas used by whooping cranes in summer are the large marsh complexes adjoining the major watercourse, the Little Buffalo River and its small tributaries (Sass, Klewi, and Nyarling Rivers). In all instances the marshes are surrounded by elements of the boreal forest. Ponds, lakes, and bogs form a patchwork within the marsh complexes and individual water bodies are separated from each other by narrow ridges. These ridges consist of hummocky terrain supporting on higher ground a relatively open, mature white spruce-black spruce-lichen forest. On lower sites the ridges contain predominantly black spruce and tamarack. The understory of the forest consists of a relatively dense shrub layer of dwarf birch (*Betula glandulosa*),

willows (*Salix* sp.), sweet gale (*Myrica gale*), green alder (*Alnus crispa*), buffalo berry (*Shepherdia canadensis*), shrubby cinquefoil (*Potentilla fruticosa*), and several ericaceous shrubs, particularly Labrador tea (*Ledum groenlandicum*).

Ponds and lakes are shallow almost without exception. Crane nests are usually constructed in relatively shallow areas and mean water depth in 75 nesting ponds (measured 1 m from the nest edge, 1975-1979) was 25.4 cm. Dominant emergent vegetation in nesting ponds is bulrush (*Scirpus validus*), sedge (*Carex aquatilis*), and cattail. All three species are used as nest material by whooping cranes, bulrush most commonly and cattail rarely. Habitat, like that described, is common in northern WBNP and breeding habitat for whooping cranes does not appear to be a limiting factor.

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CLUTCH SIZE, HATCHING SUCCESS, AND SURVIVAL OF WHOOPING CRANE CHICKS, WOOD BUFFALO NATIONAL PARK, CANADA

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Abstract: Over 90% of whooping crane (*Grus americana*) egg clutches, where eggs could be counted (1966-1980), contained 2 eggs. Some clutches could not be observed because they remained covered by the incubating bird. Predation on whooping crane eggs is minimal and hatching success of eggs left in nests during years when eggs were collected has varied from 65 to 94%, averaging 79%. In most years, mortality of chicks occurs chiefly before 20 June and chicks still alive by the end of July have a good chance of reaching the winter range at Aransas National Wildlife Refuge (ANWR) in Texas. During the last 3 years chick survival has been below the average of 7 birds, which occurred in years when eggs were collected, and chick mortality has increased during late summer. Water levels in the breeding area have declined steadily since 1977 and a relationship may exist between lower water levels, predation, and a decline in production of young cranes.

The struggle for survival by the endangered whooping crane (*Grus americana*) continues to attract public interest. The population nesting in Wood Buffalo National Park (WBNP), Canada, reached 42 birds in 1964 and had climbed slowly but steadily to almost double that number by 1980. During a comparable period of 17 years (1947-1963) the population gain was only 2 birds (Manager ANWR, pers. comm.). This paper summarizes information gathered on the whooping crane breeding range during actual egg collection and during aerial surveys over the area from 1966-1980.

METHODS

Methods employed in the collection of whooping crane eggs during regular surveys have been described elsewhere (Kuyt 1968, 1976a, 1976b). Timing of the first flight depends on the progress of snowmelt in the nesting area but is generally during the last week in April. About 10 or 12 breeding pair surveys may be required to locate all nests and to document laying dates. A further 12-15 flights are made throughout the summer and early fall to monitor survival of chicks and to record other information. Data remain incomplete for 1966 and for some of the years during which eggs were not collected. During these years there was little need to disturb incubating birds and few survey flights were made.

NEST STUDIES

Distribution

Novakowski (1966) indicated a maximum breeding population of 6 pairs in the Sass River area. He stated that 3 to 6 pairs nested elsewhere and that 2 of these pairs nested sporadically in the Klewi River area. He also found that 52% of the 61 young which returned to ANWR from 1954-1965 were produced by the 6 breeding pairs in the Sass River area. Clearly, the Klewi River area must have been of almost equal prominence as a producing area or there must have been (as Novakowski [1966] suggested) other nesting areas. My findings from 1967-1980 (Table 1) appear to corroborate that the Sass and Klewi areas are of equal importance as young-producing areas.

Although difficult to quantify, water levels during dry years seem to remain suitable for a longer period in the Klewi River area than elsewhere and in dry years the Klewi area is the better producing area. Water levels in the breeding range have decreased since 1977 (Kuyt and Johnson, unpublished data), and from 1978-1980 the breeding population in the Klewi area was greater than that in the Sass River.

After the 1st time a pair of breeding whooping cranes was found in the Alberta portion of WBNP (Kuyt 1978), a new nest site was discovered in 1980 between the Sass and Klewi Rivers. Only nonbreeding birds had been found there before (Kuyt 1979, 1981).

CLUTCH SIZE

Novakowski (1966) reported 37 clutches of whooping crane eggs in the Sass River area from 1954-1965. Only a single clutch contained 1 egg (2.7%); all others had 2 eggs (97.3%). Among 203 clutches observed between 1966 and 1980, 184 (90.6%) contained 2 eggs, 16 (7.9%) only 1 egg, and 3 (1.5%) 3 eggs. It is not known why, since 1966, the frequency of single egg clutches has increased among whooping cranes.

Novakowski used a helicopter which always causes the incubating bird to rise and is probably why he determined contents of each nest in contrast to my studies, which failed to determine clutch size in 8 nests during 1966-1972 (Table 1). I used fixed-wing aircraft during my aerial surveys over the nesting range (Kuyt 1968). Miller (1973), summarizing the findings of several other workers studying sandhill cranes (*Grus canadensis*), determined that 304 of 334 clutches (91.0%) contained 2 eggs, 28 clutches (8.4%) had 1 egg, and 2 nests (0.6%) had 3 eggs.

Egg Loss and Renesting

Loss of eggs from whooping crane nests occurs rarely. A nest and 1 egg found on 11 May 1973 was abandoned and the egg disappeared 3 days later. In 1975 and again in 1979, a nest with 2 eggs was found destroyed at the time of the egg pickup, an estimated 10-15 days before hatching.

In 1978 a late nest with 1 egg was found on 16 May on a small pond. A similarly late nest in 1979 had 2 eggs on or about 23 May. The 1978 nest was found empty and deserted on 19 May. The egg left in the 1979 nest after our egg pickup was apparently taken by a black bear (*Ursus americanus*) about 12 days before hatching. Both these nests were thought to be located in unsuitably small ponds surrounded by extensive tracts of forest.

In 1977 a rare clutch of 3 eggs was discovered destroyed 4 days after having been found. The eggs appeared to have been destroyed by large birds, perhaps by the parents.

In 1980 we found 2 nests with 2 eggs each, attended by banded 3-year-old birds. Both nests, first efforts

Table 1. Clutch size of whooping cranes, Wood Buffalo National Park, 1966-1980.

Year	Sass River				Klewi River				Nyarling River			Little Buffalo River	Nonbreeder area	Total
	2	1	3	?	2	1	3	?	2	1	?	2	2	
1966	4			1	Not surveyed				Not surveyed					5
1967	6				2	1			Not surveyed					9
1968	6				4				Not surveyed					10
1969	4	1			6	1			Not surveyed					12
1970	5	1			7						1			15
1971	6	1			4	1			1					13
1972	6			2	3	1		3	1					16
1973	6	1			5	1			1					14
1974	8				5	1			1					15
1975	6	2			6		1		1					16
1976	8				7				1					16
1977	7		1		6				2			1		17
1978	4	1			7				1	1		1		15
1979	6		1		9				2			1		19
1980	6	1			9	1			1				1	19
Total	88	8	2	3	80	7	1	4	12	1	1	3	1	211

Summary of clutch size (%)

2 eggs	87.1	86.9	85.7
1 egg	7.9	7.6	7.1
3 eggs	1.9	1.1	0.0
?	2.9	4.3	7.1

Total known clutch size (%)

2 eggs	90.6
1 egg	7.9
3 eggs	1.5

by young birds, were unsuccessful. Nest 19-80 was found empty on 29 May, the day of the egg pickup. A trail of a large mammal, presumably that of a black bear leading from the shore to the nest island, was visible from the air. Nest 18-80, also found abandoned on the day of egg pickup, contained a large part of an egg. Parts of the eggshell and the contents had been eaten. The eggshell contained no punctures and the jagged edges of the shell indicated that a mammal had eaten the egg.

The loss of a clutch of eggs (partial or complete) and subsequent renesting is only rarely documented in northern birds. On 19 April 1976, nest 8-76 was found in the Klewi River area with 1 egg. On 1 May the nest still contained 1 egg. Parts of a broken egg were observed on the nest 3 days later and the parents had abandoned the nest. A pair of cranes at a nest containing 1 egg was observed 1 km northeast of nest 8-76. That new location was only 150 m northeast of the site where a pair (undoubtedly the same pair) had a nest with 3 eggs in 1975. Nest 8A-76 (the renesting) had 2 eggs by 6 May, but neither egg hatched. Nests 8-76, 8A-76, and 10-75 were all located within the same Composite Nesting Area Klewi 7 (Kuyt 1981) and were probably produced by the same pair of cranes.

In 1980, nest 14-80 in the Klewi River area had 1 egg on 7 May, 2 eggs on 9 May, but was found abandoned and empty on 14 May. On 3 June, nest 14A-80 was found

with 2 eggs 700 m southeast of abandoned nest 14-80 and 300 m from last year's nest 15-79. Nests 15-79, 14-80, and 14A-80 are all within the same Composite Nesting Area Klewi 3. On 3 July, nest 14A-80 was still attended by an adult bird. On 10 July hatching was at least 1 week overdue and broken shells were in the nest. The adults had abandoned the nest.

The above 2 examples are the only incidences of what I believe to be renesting by whoopers who had lost their initial clutch.

Hatching Success

During years in which eggs were not collected (1966, 1970, 1972, and 1973) there was no great need to determine exact laying dates and clutch size. During the field season of 1970, 1972, and 1973 the writer spent considerable time on waterfowl surveys along the coast of Beaufort Sea, and exact numbers of eggs laid and hatched remained unknown. The numbers shown in Table 2, therefore, are minimum values, particularly during the above mentioned years.

Data for years during which eggs were collected (and for these years more complete data are available) show that between 131 and 141 eggs hatched in WBNP. The difference between number of eggs laid and collected during these years is 172 eggs, giving a hatching success of between 76 and 82%.

Survival of Chicks

In most years, mortality of chicks occurs during the young birds' first 2 weeks of life and juveniles still alive by the end of July have an excellent chance of reaching the winter range (Table 3).

From 1978-1980, however, chick losses appeared to occur throughout summer rather than being concentrated between hatching and 20 June. I mentioned earlier that water levels in the breeding range have declined since 1977. Production of young during the past 3 years has been below the average for "pickup" years (Table 3). The most plausible explanation for the change in mortality of chicks during the last 3 years is the gradual drying of the feeding terrain of parent cranes and their flightless chicks. Young whoopers and their parents almost always feed in shallow ponds and along margins of deeper ponds. When feeding areas dry up, whooper families are forced to travel farther in order to find suitable water bodies. In so doing, they expose themselves to terrestrial predators that find the marshy areas more accessible than before.

Young whoopers do not fly until 80-90 days old (R. Drewien, pers. comm.) and are vulnerable until about the 3rd week of August. In 1979 a wolf (*Canis lupus*) killed and ate a large juvenile whooping crane on 13 August (Kuyt and Johnson, unpublished data); 6 other young banded on that day, varied from 3.75 to 4.75 kg. One of the 6 young (from the nesting territory bordering the area where the young was killed) failed to arrive at ANWR and possibly was also killed by wolves.

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Table 2. Hatching success of whooping cranes in the wild, Wood Buffalo National Park, 1966-80.

Year	No. of nests	No. of eggs laid	No. of eggs collected	No. of eggs hatched in Canada	Minimum % hatching success ^a
1966	5 ^b	9-10	0	5-10	56
1967	9 ^b	17	6	10-11	91
1968	10	20	10	8-9	80
1969	12	22	10	10-11	83
1970	15	27-29	0	6-30	22
1971	13	24	11	10-11	77
1972	16	26-31	0	6-32	23
1973	14	26	0	5-25	19
1974	15	29	13	15-16	94
1975	16	31	14	11	65
1976	16	32 ^c	16	14	88
1977	17	35	16	14-15	74
1978	15	28	13	10-13	67
1979	19	39	19	14	70
1980	19	36 ^d	13	15-16	75

^a $\frac{\text{Least possible number of eggs hatched}}{\text{Least possible number of eggs laid} - \text{eggs collected}} \times 100\%$

^bData probably incomplete.

^cNot including 1 egg in nest 8-76. Egg disappeared, birds renested (2 eggs) at 8A-76.

^dNot including 2 eggs in nest 14-80. Eggs disappeared, birds renested (2 eggs) at 14A-80.

Table 3. Survival of whooping crane chicks, Wood Buffalo National Park, Canada, 1966-1980^a.

Year	No. of nests	No. of eggs hatched	Minimum no. of chicks surviving			No. of chicks arriving at Aransas ^b
			20 Jun	29 Jul	3 Sep	
1966	5 ^c	5 ^d		Data incomplete		5
1967	9 ^c	9 ^d		Data incomplete		9
1968	10	10	8	6	6	6
1969	12	12	10	?	8	8
1970	15	6-11 ^c	?	?	6	6
1971	13	10	8	6	6	5
1972	16	6-16 ^c	6	5	5	5
1973	14	5-11 ^c	5	3	2	2
1974	15	15 ^d	4	4	2	2
1975	16	11	9	8	8	8
1976	16	14	13	12	12	12
1977	17	14-15	10	10	10	10
1978	15	10-13	10	8	6	6
1979	19	14	13	9	7	6
1980	19	15-16	13-14	6	5	6?

^aAverage for 11 pickup years (1967-1969, 1971, 1974-1980): 7 chicks/year. Average for 4 other years (1966, 1970, 1972-1973): 4.5 chicks/year.

^bData from Refuge Manager, ANWR.

^cData probably incomplete (particularly in years when no eggs collected).

^dIncluding 1 set of 2 siblings.

USE OF RADIOTELEMETRY TO STUDY MOVEMENTS OF JUVENILE WHOOPING CRANES

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Recent use of radiotelemetry equipment in studies of sandhill cranes (*Grus canadensis*) has demonstrated that miniature radio transmitters could be safely and successfully employed to monitor movements and activities of *Grus* (Crete and Toepfer 1978, Toepfer and Crete 1979, Nesbitt 1979, Anderson et al. 1980, Melvin and Temple Unpubl. Prog. Reports, Univ. Wisc.). Successful results from these studies prompted the proposal that similar equipment be used to monitor whooping crane (*G. americana*) movements from the nesting grounds in Wood Buffalo National Park, Canada, to the winter area at Aransas National Wildlife Refuge, Texas, in order to provide a better understanding of their migration ecology.

United States and Canadian Wildlife Service officials, however, jointly agreed that additional experimentation was warranted before approval could be given to attach radio transmitters to flightless young whooping cranes in Wood Buffalo Park. Consequently, it was decided to evaluate the use of radiotelemetry equipment on whooping cranes reared by foster-parent sandhill cranes at Grays Lake National Wildlife Refuge, Idaho. It is possible to evaluate the use of radiotelemetry including equipment failures because members of this introduced whooping crane population are individually color leg banded and are monitored year-round (Drewien and Bizeau 1978). This paper presents findings of a radiotelemetry study of juvenile whooping cranes from August 1979 to 15 February 1980.

METHODS

Radiotelemetry Equipment

Radio transmitters similar in design to those successfully placed on sandhill cranes during 1978 in Manitoba by personnel of the Canadian Wildlife Service and the University of Wisconsin (S. Melvin and S. Temple, Unpubl. Prog. Reports, Univ. Wisc., Madison) were utilized at Grays Lake Refuge, Idaho, in 1979. Five transmitters in the 164 MHz frequency range were purchased from Telemetry Systems, Inc. (P.O. Box 187, Mequon, Wisc. 53092)².

Transmitters were powered by 10 or 20 solar cells (10 cells per panel) and 2 nickel cadmium batteries. Transmitters were epoxied to 7.5-cm-high colored plastic leg bands; antennae were 24 cm long and extended down the bird's leg. Colored leg bands with attached transmitters were placed above the tibio-tarsal joints to enhance visibility and signal transmission. Total weight of the radio package (plastic leg band and transmitter) was 45-50 g for units with a single solar panel and 55-60 g for units with 2 solar panels. Es-

timated transmitter life according to the manufacturer is 2 to 3 years. Transmitter data are summarized in Table 1.

Whooping cranes were monitored by ground and aerial tracking with AVM model LA12 receivers (AVM Instrument Co., Champaign, Illinois) and yagi "H" style directional antennae (model RA-ZAK, 164-Telonics, 1300 West Univ., Mesa, Arizona 85201). An RA-5A-164 Telonics nondirectional magnetic roof mount antenna was also used while ground tracking from vehicles. When signals were received, cranes were located either visually or with the aid of yagi directional antennae.

One juvenile whooping crane was aerially tracked in a Cessna 182 aircraft during a portion of its fall migration. Yagi antennae were attached to wing struts with mounts specially designed by Erotek Inc. (Box 547, Afton, Wyoming 83110). Strut-mounted antennae were connected to a switch box and radio receiver in the cockpit in order to follow the signals of the migrating crane. Migratory movements were plotted on sectional Aeronautical Charts (U.S. Dept. Commerce).

Trapping and Radio-tagging Flightless Young Whooping Cranes

Flightless young whooping cranes were captured, banded with No. 9 U.S. Fish and Wildlife Service bands, and individually marked with colored 3.75-cm- or 7.5-cm-high plastic leg bands in August 1979. Five young were also fitted with radio transmitters attached to colored leg bands. A helicopter was used to assist in locating and capturing the young cranes. Additional information on capturing and banding flightless young whooping cranes is presented elsewhere (Drewien and Bizeau 1978, Drewien and Kuyt 1979, Kuyt 1979).

Radio-tagged cranes were monitored almost daily from the time of capture until their fall departure in October from Grays Lake Refuge. Monitoring of movements and activities was resumed on the winter grounds at the Bosque del Apache National Wildlife Refuge, New Mexico, throughout the winter period.

RESULTS

Testing Radio Transmitters

Tests of 5 transmitters before radio-tagging young cranes indicated that 4 functioned properly but 1 emitted signals with a range of only 0.5 km. The malfunctioning transmitter was returned to the manufacturer for repair and was returned to us in late August. Reception ranges of properly functioning transmitters varied between individual units and were affected by differences in terrain, vegetative cover, and other factors. Reception ranges were tested ground-to-ground under a variety of conditions, and from aircraft to ground on 30 September. An estimate of air-to-air reception ranges was obtained on 3-4 October when we tracked 1 juvenile whooping crane during the fall migration. Reception ranges recorded were: Ground-to-ground (n = 5) 2.5 km to 8 km, aircraft-to-ground (n = 2) 25 km to 35 km, and air-to-air (n = 1) estimated 80± km.

¹A contribution of the Idaho Cooperative Wildlife Research Unit which is jointly supported by the U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, Wildlife Management Institute, and the University of Idaho (College of Forestry, Wildlife, and Range Sciences).

²Mention of a product or manufacturer does not constitute endorsement by the authors or the agency they represent.

Capturing and Radio-tagging Flightless Young Whooping Cranes

Eight young whooping cranes were captured on 6 August and 4 were instrumented. The 4 radio-tagged cranes were about 8 weeks old and weighed from 2,950 to 3,650 g when captured. Chicks which were radio-tagged were also color-marked with plastic bands for future identification after transmitters failed. A 5th crane, originally banded on 6 August, was recaptured and radio-tagged with the repaired radio on 28 August. This young whooping crane was killed by a coyote (*Canis latrans*) on 3 September. The transmitter was recovered and placed on another crane recaptured on 9 September (Table 1).

No adverse effects were noted from capturing, banding, and radio-tagging young whooping cranes. Young whoopers captured and only marked with colored leg bands were processed and released within 2.5-4 minutes after capture. Young that were radio-tagged were held 12-19 minutes. Attachment of transmitters, including gluing and sealing small openings between the transmitters and the bands, resulted in the increased time birds were held. Observations following radio-tagging revealed that the added weight of the miniature transmitters had no apparent effect upon the young cranes. As in previous years, young whooping cranes paid little attention to the new bands (Drewien and Bizeau 1978) or attached transmitters that appeared as bulges on the sides of bands. Young whoopers, however, were observed intermittently preening the antennae projecting from the transmitters.

Radio Tracking Juvenile Whooping Cranes

Ground Tracking--Young whooping cranes were monitored almost daily from time of radio-tagging until they migrated from Grays Lake Refuge between 3 and 11

October. These cranes could be observed and individually identified by their colored leg bands with a spotting scope at ranges of 1-2 km; consequently, it was possible to evaluate transmitter retention and performance. Three of 5 transmitters malfunctioned 19 to 41 days after the cranes were radio-tagged (Table 1). The 3 transmitters did not completely stop emitting signals, but only weak signals were received intermittently at normal ranges up to 3 km. When these same cranes were approached closely (400-800 m) signals were usually, but not always, received.

One of the 3 whooping cranes with a malfunctioning transmitter (bird 79-12, Table 1) was killed by a large raptor, presumably a golden eagle (*Aquila chrysaetos*) in northwestern Colorado on 13 October during fall migration. Examination revealed that the antenna was broken 1.6 cm from the point where it emerged from the transmitter. The radio was still operational but maximum receiving range was reduced to about 0.5 km.

The 4 surviving radio-tagged juvenile whooping cranes were all relocated on the winter area at Bosque del Apache Refuge, New Mexico, between 17-27 October. In New Mexico during winter, observations of the 2 surviving cranes that had malfunctioning radios before departing Grays Lake Refuge revealed that antennae were also missing from their transmitters. Apparently, malfunctioning of the 3 radios at Grays Lake Refuge was related to broken antennae which greatly reduced signal transmission distances. We suspect the damaged antennae were partially or entirely caused by the preening activities of the young whooping cranes.

Only 1 of the 4 radio-tagged whooping cranes relocated in New Mexico by late October had a transmitter that was still operating satisfactorily (Table 1). Signals from 2 other cranes wearing transmitters with broken antennae were received at maximum distances of

Table 1. Summary of data on radio transmitters placed on young whooping cranes, August 1979 to 15 February 1980.

Model	Frequency (MHz)	Pulse rates (ppm)	Drain (ms)	Whooping crane identification ^a	Date crane radio-tagged	Date transmitter last functioned properly	Status (15 Feb 1980)
RS50-2TM-3X (single solar panel)	164.320	82	0.40	79-13 ^b 79-12	28 Aug 9 Sep	23 Sep	Bird dead--13 Oct signal weak (antenna broken)
	164.454	53	0.46	79-9	6 Aug	16 Sep	Signal weak (antenna broken)
RS50-2TM-6X (2 solar panels)	164.487	134	0.78	79-11	6 Aug	15 Feb	Operational
	164.510	130	0.62	Patuxent No. 2	6 Aug	6 Oct	Inoperative
	164.537	66	0.84	79-4	6 Aug	25 Aug	Signal weak (antenna broken)

^aIdentification numbers (79-series) were assigned by E. Kuyt, Canadian Wildlife Service, at time of egg pickup in Wood Buffalo National Park, Canada. Patuxent No. 2 originated from an egg produced by a captive pair of whooping cranes at Patuxent Wildlife Research Center, Laurel, Maryland.

^bWhooping crane 79-113 was killed by a coyote on 3 September. The transmitter was removed and placed on 79-12 on 9 September.

0.5 to 1 km during ground surveys. One transmitter which was operational on 6 October was inoperable by late October (Table 1). The status of the transmitters remained the same through mid-February 1980.

Although signal reception distances of the 2 transmitters with broken antennae were greatly reduced, it was still possible to locate the individual birds in order to monitor their daily activities. All 3 juveniles confined their winter activities, between late October and mid-February, to the Bosque del Apache Refuge and adjacent areas within 8 km. All 3 foster-parent families roosted nightly in the refuge roost area. Two families confined most of their daily activities to the refuge, while the 3rd frequently foraged in private lands outside the refuge.

Aerial Tracking--The aerial tracking system was tested on the 5 radio-tagged cranes on 30 September. Signals from the 3 birds with the malfunctioning radios could only be received within 2 to 4 km, air-to-ground. Signals from 2 cranes with fully operational radios (Table 1) were received 25-35 km air-to-ground from an elevation of 3,050 m. As a result of these findings, we decided to track the 1st juvenile whooping crane that migrated from Grays Lake Refuge with a fully operational transmitter.

On 3 October, a foster-parent pair with a radio-tagged juvenile, 115 days old, initiated the fall migration. This juvenile was hatched by its sandhill crane foster-parents from an egg produced by a captive whooping crane at Patuxent Wildlife Research Center, Laurel, Maryland. The juvenile was tracked by air for 800 km without difficulty for 3 consecutive days until the family arrived in the San Luis Valley, Colorado, the major fall migration stopover area utilized by cranes from Grays Lake, Idaho (Drewien and Bizeau 1974). Radio contact was maintained daily except for periods when we landed to refuel the aircraft. Visual contact was also made daily. The foster-parent family completed this segment of the migration in about 17 hours of flying time during the 3-day period.

The migration pattern of the foster-parent family was typical of that which we have observed among sandhill cranes. Daily migrations are normally initiated late in the morning and terminated before sundown. After the daily migration began the family did not land until it arrived at the night roost site. Flock size was not constant; numbers of sandhill cranes in the flock with the foster-parent family changed daily and sometimes during the same day.

Table 2. Summary of the fall migration of a greater sandhill crane foster-parent pair with their radio-instrumented juvenile whooping crane (Patuxent No. 2), Grays Lake NWR, Idaho, to the San Luis Valley, Colorado, 3-5 October 1979.

October	Departure location	Departure time (hours)	Arrival location	Arrival time (hours)	Distance migrated (km)	Flight time (hours:min)
3	Grays Lake NWR, ID	1150	Henry's Fork, WY	1744	264	5:54
4	Henry's Fork, WY	1152	Grand Mesa, CO	1809	276	6:17 + 15-30 min ^a
5	Grand Mesa, CO	1054	San Luis Valley, CO	1543	262	4:49
Total					802	16:50 + 15-30 min ^a

^aThe whooper was in the air about 10 km from the roost site when we located it at 1152 hours. We estimated that the bird was flying for 15 to 30 minutes before we located it.

Calculated map distance covered by the foster-parent family during the 3-day migration was 802 km. Distances traveled daily were remarkably equal, averaging 267 km per day (range 262-276 km). All distances were minimum values calculated from aeronautical flight charts. Cranes actually flew considerably farther than indicated by map distances. Time was spent spiralling on thermals to attain higher altitudes at various points along the route. Significant climbs in altitude also were made to cross major mountain ranges. Calculated travel distances do not reflect these events. A summary of the migration data is presented in Table 2 and Fig. 1.

A high-pressure system located over Nevada and western Utah dominated the weather during the 3-day migration period, 3-5 October. National Weather Service data from Salt Lake City, Utah, and Grand Junction, Colorado, showed that winds aloft (at approximately 3,050 m) favored the cranes during their migration; prevailing winds were from the northwest (320-360°, wind speeds 5 to 15 knots).

On the 1st day (3 October) the foster-parent family flew nearly 6 hours through southeastern Idaho and southwestern Wyoming. The flock roosted for the night in a small livestock-watering reservoir along Henry's Fork of the Green River (Fig. 1) near Lonetree, Uinta County, Wyoming. The stock reservoir was within 0.8 km of a ranch headquarters. Henry's Fork flows eastward along the north base of the Uinta Mountains.

On 4 October, the flock containing the radio-tagged juvenile was located at 1152 hours, 10 km from the night roost site, spiralling on late morning thermals to attain sufficient altitude to cross the Uinta Mountains. The flock spent an hour climbing about 1,225 m and then crossed the mountain pass at 1245 hours, flying at an altitude of about 3,350 m. The birds then descended to about 2,300 m as they passed over the Green River near Vernal, Utah, and continued south-easterly into Colorado near the place where the White River leaves Colorado (Fig. 1).

The cranes again climbed to 3,200 m as they crossed the Roan Plateau. At 1733 hours the flock crossed the Colorado River near the confluence of Clear Creek and continued to the foothills of Grand Mesa. They stopped for the night in a dry meadow on a brushy hillside on the west slope of Grand Mesa.

The following morning (5 October) the foster-parent family was found foraging in an agricultural field

near Molina, Colorado, about 6 km north of the roost site. The birds were airborne by 1054 hours and spent the next hour climbing the west slope of Grand Mesa. The flock passed over Grand Mesa at 1206 hours at an altitude of 3,600 to 3,660 m.

The cranes maintained this altitude and, with the assistance of a strong tailwind (15 knots, 350 $\frac{1}{2}$), migrated directly toward the San Luis Valley. They crossed the Continental Divide at 1504 hours south of Cochetopa Pass flying at an altitude of 3,630 m and landed in a wet meadow 1.5 km north of Monte Vista National Wildlife Refuge at 1543 hours. The family remained in the area during their 2.5-week stay in the San Luis Valley, Colorado.

The juvenile whooper and its foster-parents were located on the winter grounds at Bosque del Apache Refuge, New Mexico, on 27 October but the transmitter no longer functioned.

DISCUSSION AND CONCLUSIONS

Considerable data have been obtained on juvenile whooping cranes reared by sandhill crane foster-parents during the 6 months since birds were first radio-tagged. The use of radiotelemetry equipment provided us with the ability to rapidly locate and monitor individual whooping cranes both on their summer areas in Idaho and some 1,200 km southeast at their winter site in New Mexico. Information was acquired on their daily and seasonal movements, activities, and causes of mortality.

Problems were not encountered in capturing and radio-tagging young whooping cranes. All sandhill crane foster-parents rejoined their radio-tagged young shortly after they were released. The only unusual behavior we observed in young whoopers as a consequence of their being radio-tagged was their preening of transmitter antennae, which occurred primarily in the 1st month after banding. The plastic leg bands with attached transmitters did not appear to hinder or otherwise adversely affect the young cranes.

Aerial tracking of 1 juvenile and its sandhill crane foster-parents during fall migration provided some insight into crane migration characteristics. The flight speed of the foster-parent family over the 3-day, 800 km route averaged 46-47 km/hour. The maximum daily flight speed recorded averaged over 54 km/hour on 5 October. The foster-parent family had the advantage of northwesterly tailwinds throughout the 3-day migration period. A maximum migration altitude of over 3,600 m was recorded on 2 occasions when the cranes flew over high mountains in Colorado. Much of the migration was made at altitudes above 2,750 m. The 3 daily departure times were in late morning, after 1050 hours, and arrival times at night roost sites were near sundown. The family flew from 5 to 7 hours per day (mean 5.7 hours).

Migration data obtained for the juvenile whooper and its foster-parents are generally similar to that reported for the Eastern population of greater sandhill cranes (Crete and Toepfer 1978, Toepfer and Crete 1979, Anderson et al. 1980). Anderson et al. (1980) reported an average daily migration of 297 km/day (range 115-530), morning departure times ranging from 0800-1033, cranes flying 6-8 hours daily, and landing near sunset. Crete and Toepfer (1978) and Toepfer and Crete (1979) found that cranes flew 272-484 km/day and landed before or at sunset. The above-mentioned studies all reported that cranes generally migrated with favorable tailwinds.

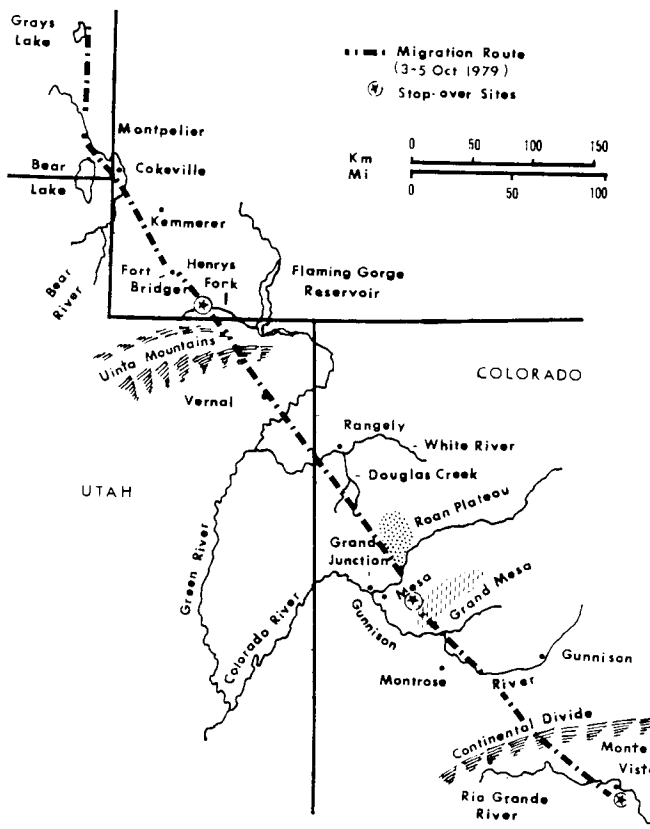


Fig. 1. Fall migration route of 1 greater sandhill crane pair with their radio-instrumented juvenile whooping crane, 3-5 October 1979.

The major technical problem encountered during the initial 6 months of the study has been the partial or entire malfunctioning of most transmitters. Only 1 of 5 transmitters was still properly operating 3 months after placing them on birds. Three transmitters sustained broken antennae which significantly reduced transmission ranges. Loss of antennae was apparently caused by the cranes' preening activities. A 4th transmitter completely failed after 2 months due to unknown technical difficulties.

Before radio-tagging more whooping cranes, improvements in transmitter design, especially antennae, are needed to reduce technical problems encountered in the current study. The manufacturer has indicated that stronger antennae will be installed on new models to be tested in 1980. We are also investigating ways of reducing the handling time of young cranes being radio-tagged. This could be accomplished by attaching the transmitters to plastic leg bands before capture. Instead of permanently epoxying transmitters to leg bands, we are currently testing the use of miniature screws that are susceptible to corrosion 1-2 years after contacting saline water. Transmitters would then be jettisoned from the leg bands after their serviceable life and thus eliminate any future encumbrance to the cranes. If current technical problems are corrected, the radio-tagging of young whooping cranes on the Canadian nesting grounds could be accomplished with negligible impact upon the birds. Considerable data could then be obtained on their migration ecology.

ACKNOWLEDGMENTS

We thank C. Eugene Knoder, National Audubon Society, for flying the aircraft during aerial tracking. We especially acknowledge the National Audubon Society for the generous allotment of C. E. Knoder's time and contribution of one-half of all aircraft costs. We thank Amos Eno, U.S. Fish and Wildlife Service, for assisting in aerial tracking and in other phases of the radiotelemetry study. We acknowledge the assistance of S. Melvin, University of Wisconsin, Madison, in radio-tagging young whooping cranes, and of S. Somesen in helping to ground track cranes in Idaho and New Mexico. We appreciate the advice of officials of the U.S. Fish and Wildlife Service and the Canadian Wildlife Service and for permission from those agencies to radio-tag whooping cranes. The project was funded by the Office of Endangered Species, U.S. Fish and Wildlife Service (contract 14-16-0008-1178).

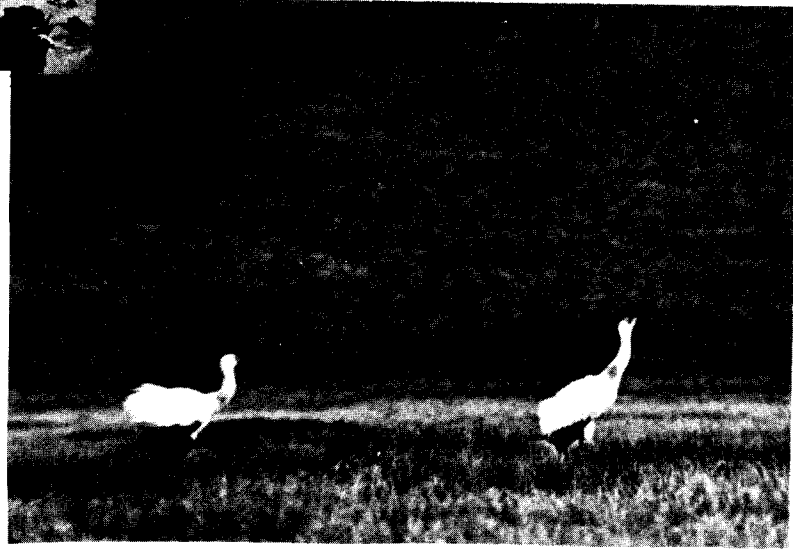
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Siberian Crane



Immature Siberian crane.



Adult Siberian cranes (both photos by E. Nazarov).

THE SIBERIAN CRANE IN YAKUTIA

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The Siberian white crane (*Grus leucogeranus*) nests only within the USSR and is very rare. Its basic biological characteristics are almost unknown and in some instances the published facts are erroneous, even though in the past 15 years serious attention has been paid to the study of this crane, and the findings have been published in both general and specialized works. Unfortunately, the inaccurate information can be found in works published in several countries, including the Red Data Book of the International Union for the Conservation of Nature and Natural Resources, which lists the Siberian crane as a disappearing species.

Two discrete nesting areas exist; most likely each is a separate population. The Ob population of 80-100 birds can be found in the lowlands of the lower reaches of the Ob River; the Yakut population resides in low areas of the tundra in northeastern Yakutia.

We studied the biology and distribution of the Siberian white crane in Yakutia in 1965 and in 1971-1973. Both authors studied in the delta of the Indigirka River in 1971. In the other years, V. E. Flint investigated the shrubby tundra within a 30-km radius of Berelyakh in the Allaykhovskii District of the Yakut Autonomous Soviet Socialist Republic. Along with these ground observations, several airplane and helicopter flights were made over a large part of the range of the Siberian white crane (from the Khroma River in the west to the Sundrun River in the east). P. S. Tomkovich, a student at Moscow State University, was a great help to the authors, and we take this opportunity to express our gratitude. Others who gave us valuable information are mentioned in the text.

DISTRIBUTION OF THE YAKUT POPULATION OF THE SIBERIAN WHITE CRANE

Summer Area

Our own observations, data published by others, questioning of local hunters, reindeer herdsman, fishermen, and pilots, and discussions with zoologists who have at various times done research in the tundra, forest-tundra, and northern taiga between the Yana and Kolyma Rivers, have all enabled us to make a map of the places where nests or nestlings of the Siberian white crane were encountered, and to delineate the approximate area where at present this bird nests and was regularly found in summer from 1960-1973 (Fig. 1).

The westernmost edge of the range of the Siberian white crane is the area between the Omoloy and Yana Rivers (Roshchevskii 1973). In the eastern delta of the Yana River a pair was observed by A. A. Kistchinski and S. M. Uspenskii from 4 to 7 July 1972 but it could not be determined whether or not the birds were nesting. A little farther east, along the lower reaches of the Chondon River, a Siberian white crane nest containing eggs was found by Yu. K. Roshchevskii in 1970; he also states that the crew of a helicopter saw cranes and fledglings at a location 71° N by 142° E. According to G. B. Perelomov, a hunter, nesting Siberian white cranes have been recorded in the Ust-Yansk district (no particular place was mentioned).

Farther east, a large number of either nests or

young birds was noted in the bogs of the tundra in an area bounded roughly by the Berelyakh (also known as Elon), Khroma Lapcha, and Gusinaya Rivers, and by the Russko-Ustinskaya arm of the Indigirka River. In this area in 1960-1962, V. I. Perfiliev found 10 nests; Flint found 1 in 1965 (Flint 1970) and 1 again in 1972. In this area were observed most of the pairs that (1) S. G. Priklonskii and S. M. Uspenskii (pers. comm.) recorded in 1960 while conducting an aerial census, (2) that were sighted by Flint in 1972-1973 on both overland trips and helicopter flights, and (3) that were reported in 1972-1973 by E. V. Edukin, director of the Berelyakh section of the Sovkhozimeni Chkalov (Chkalov Memorial State Farm).

A little south of the Berelyakh River, near Et-Khatarbyt Lake, Vorobiev (1963) found a nest in 1960. According to E. P. Stepanchenko (pers. comm.), the pilots of the local airlines always observe separate pairs of cranes in the forest-tundra between the Berelyakh and Allaykha Rivers, where the Siberian crane, it seems, is comparatively common. E. V. Edukin told us that pairs of cranes are regularly encountered also on the tundra along the left bank of the Khroma River. The Siberian white crane has not been known to nest north of the Gusinaya River.

East of the Indigirka River the Siberian crane's range becomes quite narrow. It is bounded on the north by the sea (and the crane definitely does not nest on the tundra of the delta here), and on the south by the wide Kondakovskii Upland. In this section of the bird's range several pairs and individuals were noted by Priklonskii and Uspenskii during their census in 1960, and by us in 1971, along the lower reaches of the Keremesit, Shandrin, and Sundrun Rivers. Along the Keremesit River on 8 August 1971 we saw a pair of cranes with a half-grown chick. We also know of a nest that was found in 1971 by people living near the town of Polyarnii.

Farther east, in the lower and middle reaches of the Alazeya, Chukochia, and Konkovaya Rivers, crane sightings again are sporadic, although the range widens to the south. Information about these sightings can be found in articles by Vorobiev (1963, 1967) and Egorov (1971). We have been told that cranes nest in the lower reaches of the Alazeya and by Lake Bolshoi Oler between the Alazeya and the Chukochia Rivers.

Lake Bolshoi Morskoe marks the easternmost extent of sightings of Siberian cranes; B. N. Andreev told us that in 1972 he found 6 pairs there, some with young. The southern-most part of the Siberian crane's range is a group of lakes 120 km northeast of Sredne-Kolymsk, where in July 1968 V. G. Krivosheev saw 3 pairs (pers. comm.). In the present century there is no authentic record of the Siberian crane along the lower reaches of the Kolyma or on its right bank. These cranes have not been observed in summer south of the Kondakovskii Upland nor in the valleys of the Indigirka.

There is good reason to suppose that in both the western and in the eastern peripheries of the range Siberian cranes nest "in patches" of 3-6 pairs, about 100 km apart. This assertion is based on the personal

communications from V. G. Krivosheev, B. N. Andreev, and G. B. Perelomov already mentioned in the text.

Therefore, the summer range of the Yakut population of the Siberian white crane includes the typical and southern tundra, the forest-tundra, and possibly the very northern part of the taiga between the Yana River in the west and the Kolyma River in the east. The Siberian crane does not nest on arctic tundra and only single birds are encountered there, and those infrequently. Within its nesting area the crane does not nest on the lowlands of river deltas near the sea, on river floodplains, or on dry elevations and uplands. Thus, the main part of the summer nesting range is probably about 130,000 km² however, the territory containing a fairly dense population and regular nesting is hardly larger than 30,000 km². Some of the birds spend the summer outside of this area. For example, in the middle of July 1959 1 crane was collected near the mouth of the Tamma River, 50 km south of Yakutsk (G. P. Larinov, pers. comm.); on 7-8 July 1959, 6 birds were seen along the middle reaches of this river.

Migration and Wintering

The spring and summer migration routes and the wintering grounds of the Yakut Siberian crane are still a mystery. Most observations during spring migration (Uspenskii et al. 1962, Vorobiev 1962, 1967, Perfiliev 1963, 1965) were made in the valleys of the lower reaches of the Indigirka and Alazeya Rivers, that is, on a "direct approach" to the nesting grounds. The only places in this country far from the nesting area where cranes were seen are the middle reaches of the Barguzin River (where on 10 May 1962 V. E. Flint saw 2 adult birds), and the lower reaches of the Amur River (where on 5 April 1965 V. G. Panchenko (pers. comm.) saw 1 near Lake Bolon). Cranes were seen flying north along the lower Lena River near the town of Sektyakh in the spring of 1956 (Kapitonov 1962).

During the autumn migration, V. G. Krivosheev sighted a pair of cranes with a juvenile on 16 September 1962 in the vicinity of Sredne-Kolymsk (Vorobiev 1963). Farther south there is only 1 verifiable record for recent years: from 12-20 August 1965, 6 white cranes were observed on the floodplain of the Borzi River (A. N. Leontiev, pers. comm.). Besides this, in the area where it has been suggested cranes migrate in the fall (near Lake Baikal and along the Amur River) some qualified ornithologists (G. V. Gagina, I. B. Izmailov, I. A. Neufeldt, O. K. Gusev, and G. K. Borovitskaya) have worked for a long time but never mention Siberian cranes in their writings. It appears that if these cranes fly over these areas then they do so only in a random fashion, at a great altitude, and for very short periods of time.

Before the 1940's when the borders of our country changed, Siberian cranes were commonly sighted during spring (end of March-beginning of April) and fall (October-beginning of November) migrations along the northwest shore of the Liao Dun and Bohaivan Gulfs [Zaliv Liaodunskii, Zaliv Bohaivan] (LaTouche 1933, Hemmingsen and Guildal 1968). During 2 springs and 4 autumns in 1942-1945, which A. Hemmingsen spent near Pei Tai Ho and Tsin Huan Dao (on the northwest shore of the Liao Dun Gulf), he recorded a total of 984 birds, including 2 flocks seen 28 March 1945, which numbered 200-300 birds. A reader might think that in those years the whole Yakut population of Siberian cranes flew along this narrow corridor, but that so many birds would be found in separate flocks seems to

us an exaggeration. Whether the cranes still migrate in spring over this region is not known. However, there is no doubt that in the past 20 to 30 years the ecology of northwestern China has changed due to a sharp increase in human population and all the consequent circumstances; this change must have had some effect on the migration of cranes too. In Japan the Siberian white crane has been recorded only passing through in certain years (Y. Yamashina, pers. comm.).

Even less is known about the wintering grounds of the Siberian crane's Yakut population. It is widely believed (Sudilovskaia 1951, Makatsch 1959, Walkinshaw 1973) that the Siberian crane spends the winter on the lower reaches of the Yangtse River; this idea is based exclusively on the data of LaTouche (1933). However, LaTouche presents no factual evidence to support this idea; he writes: "The white crane migrates back and forth along the shores of North-Eastern China to its winter quarters on the Lower Yangtse and farther into North-Western India. In China it is known only in the area of Chi-li (the western shore of Bohaivan Gulf) and the Yangtse." It is hardly possible to consider this a convincing proof of a wintering ground on the Yangtse, especially because LaTouche did no research on the Yangtse; by analogy, this "wintering grounds on the Lower Yangtse" can refer also to many other cranes: hooded (*Grus monachus*); common (*G. grus*); white-naped (*G. vipio*); red-crowned (*G. japonensis*). David (David and Oustalet 1877) spent much more time in China and considered the Siberian white crane a very rare bird; somehow this conflicts with the idea of the regular wintering ground of the entire Siberian crane population, which at that time was probably at least 1,000 individuals.

One also cannot ignore the fact that the Yangtse Valley is one of the most heavily settled agricultural regions and even if the Siberian crane did winter there in the past, we have little reason to believe that it continues to do so now.

LaTouche's (1933) suggestion that the Siberian cranes fly over China to winter in northwestern India, is worth considering. A wintering ground in Ghana Bharatpur, now a wildlife reserve, has been known for a long time. Siberian cranes wintered there regularly until 1880; after that they disappeared. In 1960 in Bharatpur 3 birds were seen again; since then this area has been reestablished as a wintering ground, although the total number of birds that spend from the middle of December to the beginning of March there fluctuates between 30 and 200, being usually 70-80 birds (Walkinshaw 1973). Only a dozen Siberian cranes spent the winter of 1969-1970 in this reserve (Savage 1970), but at the same time (26 March 1970) Koning discovered 76 cranes in Afghanistan near Lake Ab-I-Estada (Koning 1972). Recently Lake Ab-I-Estada dried up, and the number of cranes in Bharatpur again rose to 70-80¹. Therefore we can state with assurance that India and Afghanistan are among the Siberian crane's wintering grounds, within which the birds move about.

If we also consider their regular appearance during migration in the Turgaiskaya Depression and in the reserve in Astrakhan, and the absence of any data at all concerning observations of Siberian cranes in countries of the Near East and Asia Minor, then we can safely say that the Ob River population spends the winter in India and Afghanistan. This wintering area

¹G. Archibald indicates only 30 individuals wintering at Bharatpur in 1980-81 (Editors' note).

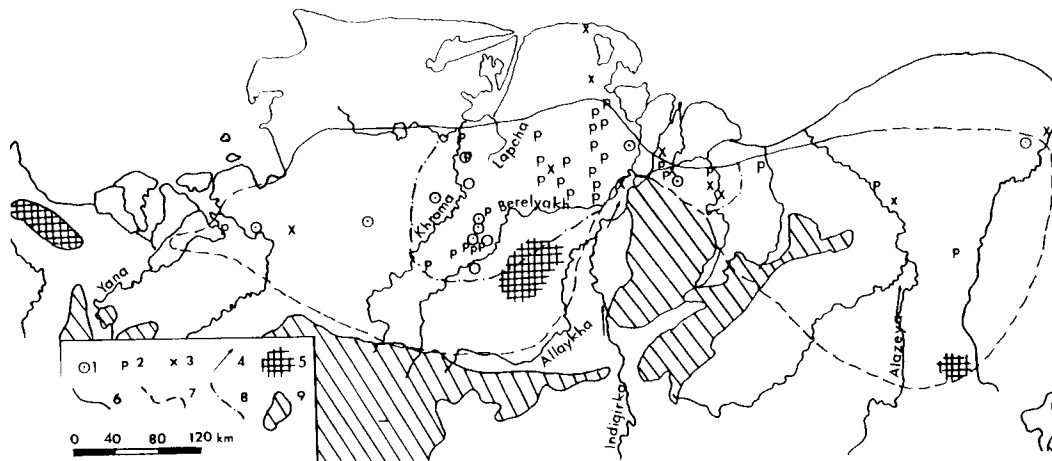


Fig. 1. Summer habitat of the Yakutia population of the Siberian crane based on data collected by Uspenski et al. 1962, Vorobiev 1963, 1967, Perfiliev 1963, 1965, Egorov 1965, 1971, Roshchevskii 1973, observations by the authors 1965-1973, and interviews with local people. Key to symbols: (1) Places where nests or chicks of Siberian cranes were found. (2) Places where pairs were encountered. (3) Places where single or lone birds were encountered. (4) Places where cranes were observed during spring migration. (5) Places where cranes were encountered more than once (according to others) but that cannot be pinpointed. (6) Limit of nesting area. (7) Limit of nesting area, approximate. (8) Limit of "main part" of nesting area. (9) Hilly areas.

is all the more likely because the total number of cranes that pass through Kazakhstan and the reserve in Astrakhan is close to the number usually observed on the wintering grounds in Bharatpur.

In contrast, the few (though reliable) records of Siberian migrating near Lake Kukuror (Przhevalskii, pers. comm.), over the Himalayas (Donald 1952), in northern Mongolia (Radde 1863), and near Lake Baikal, together with a spontaneous growth of the number of cranes wintering in the reserve at Ghana Bharatpur to 200 individuals in some years, lead us to believe that part of the Yakut population also winters in India. Obviously this conjecture needs further documentation.

In summary, where the Yakut population spends the winter is still uncertain. It is possible that this population's wintering grounds are not fixed and the birds are widely dispersed. This is a very important question to answer because the survival of *G. leucogeranus* depends on it.

AGE DISTRIBUTION, SOCIAL STRUCTURE, AND SIZE OF POPULATION

Plumage Changes with Age

In characterizing the ages of Siberian cranes, modern researchers generally go no further than the most general categories: "adult," "young," "immature" (Uspenskii 1961, Perfiliev 1965). However, Hume (1868) observed that the final plumage of this crane, as of other large birds, takes several years to grow. Our research supports his observation. During our field work we were able to observe 26 birds at fairly close range through binoculars. We added data from these observations, data we had collected, and published data (Uspenskii et al. 1962, Perfiliev 1965); an analysis indicated the following 4 age groups.

Age 1 year.--The white plumage of the body and wings is thickly sprinkled with yellow-gray blotches.

Thus, a bird in flight looks not white but grayish, especially when seen against the light. The legs, beak, and unfeathered area of the head (the "face") are dark (appearing black at a distance).

Age 2 years.--Plumage is generally white, but conspicuous dark patches are on the back of the head, the rear side of the neck, and on the back between the wings. Some of the wing feathers are yellow-gray. The beak and face are dark but the legs and feet are already red.

Age 3 years.--Plumage is snowy white except for the rear side of the neck and part of the back between the wings, where some gray remains. Legs and feet, beak, and the bare skin on the head are red.

Age 4 years and more.--Plumage is snowy white; legs, feet, beak, and bare skin on the head are all red. It may be that this plumage is not attained until the bird is 5 years old.

Age Structure of the Population

The age distribution of the population within the nesting area can be characterized in the following way (Table 1) if we consider all the birds that we observed, or about which there is reliable data, as a random sample of the population.

The pairs who had a well-defined nesting territory were 3 years old or older, consequently, we conclude that the Siberian crane must be at least 3 years old before it can reproduce. Hume (1868) says the same thing, and G. Archibald (1973) has found that other large cranes are similar. Thus, if the percentage of birds potentially capable of reproduction is about 75%, then the percentage of subadult birds must be 25% of the total population. This percentage of subadults reaffirms the idea that some young birds spend the summer outside of the nesting area.

Social Structure of the Population

Even though 75% of the population is sexually mature, that still does not indicate a high reproductive potential of the population. Reproductive potential depends on the combination of birds of different ages (the social structure) during the nesting period and on the origins of these combinations. Let us examine all of the adequately recorded combinations of cranes observed during our research to determine what the necessary combinations are.

Single birds.--All recorded encounters of lone birds pertain to immature individuals 1 or 2 years old.

Pairs.--The age combination of pairs can vary. (A) Adult bird 4 or more years old and yearling bird. We saw 2 such pairs; doubtless they were the remnants of families in which 1 parent had died during migration. The chick born the year before accompanies its parents back to the nesting ground and leaves the parents only when they form a nesting territory (Neufeldt 1973, Walkinshaw 1973). The only apparent exception is the whooping crane (*Grus americana*) (Novakowski 1966).

(B) Adult bird 3 or more years old and a young bird 2 years old. Pairs of this combination maintain a clearly defined territory for the duration of the nesting season but do not reproduce. Such pairs (we encountered 3) are probably newly formed and in the

1st year of their "conjugal" life; they constitute the potential reproductive reserve.

(C) Two adult birds 3 or more years old who are a territorial pair. Among the 5 pairs like this that we observed, 2 were definitely nesting. These 5 pairs represents the actual reproductive reserve; however, this actuality is quite relative, depending on mortality rates of eggs.

Groups of 3 or more birds.--On 6 June 1973 we saw a group of 3 adult cranes who acted as if they were "passing through" on their way to a nesting area. However, since the nesting season was already advanced, it is improbable that they found mates that year.

Thus, the nonreproductive part of the population (the "reserve" of unmated birds) within the nesting area is not less than 61.5% of the total and the actual reproductive part (again, ignoring egg mortality) only 38.5%. About 80% of the Siberian cranes we saw in the summer of 1973 were in pairs but only 62% were territorial. Among the cranes who were in pairs only half can be conditionally included in the category of "nesting." This percentage nesting must always be taken into account when analyzing and extrapolating data from aerial censuses.

Population

A serious evaluation of the present numbers of the Siberian crane is 1 of the tasks essential to devising measures to preserve this species. Data published about this question are contradictory. Vorobiev (1963) estimates the total population of Yakut Siberian cranes at 200-250 nesting pairs; Perfiliev (1965) at 300-350 nesting pairs; Uspenskii (1961) at 500-700 pairs. Egorov (1971) lists the most optimistic number--1,500 individuals. Our data indicate that the Yakut population of *Grus leucogeranus* in 1971-1973 was about 100 territorial pairs and 100 unmated birds, or about 300 in all (Table 2).

This brings up the obvious question: how can 1 explain the discrepancies in the population estimates of various researchers? Is this the result of a genuine decline in population at the end of the 1960's or is it due to different methods of census. This problem is important and to solve it 1 must analyze the primary raw data.

To determine the population of the Siberian crane in 1971-1973 we used data on the density of the population in the "main part" of the range, where population density is highest (Fig. 1). We obtained these data by 2 means. First, we measured the average dis-

Table 1. Age distribution of Siberian crane population.

Age	Number	Percentage
1 year	3	7.3
2 years	7	17.0
3 years	14	34.1
4 and more years	17	41.6

Table 2. Yakut population of the Siberian crane based on data of several biologists.

Biologist	Year(s)	Population estimate
Uspenskii (1961)	1960	500-700 nesting pairs
Vorobiev (1963)	1960-1962	200-250 nesting pairs
Perfiliev (1965)	1960-1962	300-350 nesting pairs
Egorov (1971)	1963-1964, 1966	1,500 individuals
Flint and Kistchinski	1971-1973	300 individuals

tance between territorial pairs. In 1972 between the settlement of Berelyakh and the Khroma River we noted, from a helicopter and on trips on the ground, 5 pairs nesting (near the Lakes Baranaattalaakh and Diyara-Kyuel, on the Adyagyr Hills, on the northwest corner of Lake Byugyucheen, and near the ocean). In 1973 there were territorial pairs on the same spots. The shortest distances between them were respectively 30, 27, 14, and 30 km, an average of 25 km. From this average we can conclude fairly safely that the average nesting pair occupies a territory of 625 km². Then, if territorial pairs are 62% of the total population in the nesting areas, average density is equal to 5.1 individuals, or fewer, per 1,000 km².

The second method for determining population density is a fixed-itinerary census from the air. On 8 August 1971 between the Khroma, Gusinaya, Indigirka, and Sundrun Rivers, i.e., in the area of high population density, an aerial census was made covering a total distance of 770 km; the census "corridor" was 3 km wide. Thus the census area covered 2,300 km². In it we saw 11 Siberian white cranes, including 1 pair with a juvenile. Calculations yield a population density of approximately 4.8 individuals per 1,000 km² where both territorial pairs and single birds are found.

The similarity of results achieved by the 2 different methods of counting support the accuracy of both. In any circumstance these data are quite accurate for the central part of the crane's range, where the population density can be said to be 5 individuals per 1,000 km², including 1 or 2 territorial pairs. By applying this index to the "main part" of the nesting area, 30,000 km², one calculates a total population of 150 white cranes, including 50 territorial pairs. Then, considering the extensive but sparsely settled peripheral part of the Yakut population's range, we arrive at a final figure of 300 birds, including 100 territorial pairs and 100 birds in the unmated "reserve."

Let us now consider the raw data of our predecessors and their conclusions. Vorobiev (1963) does not provide any support for his estimate. Perfiliev's (1965) conclusion is also not discussed. Although Perfiliev (1965) had available to him numerical data from a route census (length of route in 3 field seasons: 900 km, 107 birds sighted, 10 nests found), he made no calculations from them to determine the total population, but limited himself to a vague indication ("on the basis of our research"). However, if we retrospectively analyze Perfiliev's numbers, we find that he is on the right track when he says that in 900 km he found 10 nests. If we assume that half of the pairs of Siberian cranes are nesting pairs (see above)

and that the nests of most of the nesting cranes were found (and Perfiliev made an effort to do this), then the calculable distance between separate territorial pairs turns out to be near to what we noted.

In contrast to the researchers mentioned above, Uspenskii (1961) gives rather detailed support to his population estimate. On the basis of aerial censuses (the length and width of the routes he followed unfortunately are not stated) he concluded that the distance between nesting (it would be more accurate to say "territorial") pairs varies between 12-14 km and 30-35 km, with an average of 20 km. From this he determines a population density of 25 nesting pairs per 100 km², and then, by extrapolation to an area 2,500-3,000 km² he concludes that the total population is 500-700 nesting pairs.

It is not difficult to notice that there are several mistakes in Uspenskii's elementary arithmetic, including 2 in determining the population density and 1 in estimating the area. One might be able to excuse these mistakes as typographical errors, but the same numbers and conclusions did appear word-for-word in a later publication (Uspenskii et al. 1963). Regrettably, it was these data that were officially published in the Red Data Book of the International Union for the Conservation of Nature. In actuality these same basic facts (on the distances between territorial pairs) are correct and are similar to ours.

Some very fundamental calculations can be found in the research of O. V. Egorov (1971). He censused from an airplane and a helicopter in 1963, 1964, and 1966. Over a course of 1,650 km total, with a width of 1 km, he sighted 77 Siberian cranes; this gives a population density of 0.45 to 0.50 individual per 10 km². Assuming a range for this crane of 32,000 km², Egorov determined a total population of 1,500 individuals. His calculations are irrefragable.

However, 2 circumstances influencing Egorov's work must be considered. First, the width of his census "corridor" was only 1 km, or 0.5 km on either side of the airplane or helicopter. The Siberian crane is a large and conspicuous bird and in the latter part of the summer, with the green tundra as background, can be seen from as far away as 1.5, sometimes even 2 km. A certain psychological factor enters here: the crane attracts the interest of the census taker, and we, who have ourselves made aerial censuses, simply cannot imagine a crane, who had been sighted at a distance of more than 0.5 km, would not be included on the census map. In other words, we think that truly accurate census data can only be taken using "corridors" not less than 3 km wide.

Second, Egorov refers in an earlier publication (Egorov 1965) to the census that he made in August of 1963, but he describes it with completely different parameters: the length of his route is given as 800 km (instead of 400) and the width of the "corridor" is only 0.5 km (instead of 1 km)².

²That this is indeed the same route is proven by the complete consistency of the census data and the way in which they are restated.

At first glance this retrospective change of the parameters of the census itinerary ought not to have an effect on the end result, because the area censused is the same. But what does change, and radically, is the frequency of encounters, that is, the number of birds recorded per unit of the itinerary. Therefore, we suggest that the actual length of the itinerary should be that which the researcher himself mentions in this earlier work. If we add the psychological factor mentioned above, the results of the census are much different. Eighteen cranes were sighted on an itinerary 800 km long and 3 km wide; this gives a population density not of 45 individuals per 1,000 km², as Egorov states, but of only a little more than 7 cranes per 1,000 km², which agrees with our data.

Therefore, comparative analysis of the original data shows that the variations in estimates of the total population by various authors came about not through any actual change in the situation of the cranes but simply through methodological errors. There is reason to assume that the population of this crane is now relatively stable and if any recent population decline did occur, it was insignificant.

The historical aspect is somewhat different. Ignoring for the present the debatable question about the historical distribution of this crane, to which a special publication will be devoted, we can still definitely perceive a decline in the numbers of this species during the past 2 centuries. Authoritative records of this crane in summer in the region of the Ural Mountains, in Kazakhstan, in Western Siberia, and near Lake Baikal, which are summarized by Kirilov (1966), do not mention the crane's nesting in those places and, therefore, probably pertain to unmated wanderers. Naturally, these birds were only part of the population, and the numbers recorded exceed modern records; the latter hypothesis is further supported by observations of huge flocks in transit, sometimes as many as 300 birds (Kirilov 1966).

The actual size of the population of Siberian white cranes is now dangerously small, the rate of reproduction is slow, and these factors along with the historical tendency towards a continuing decline in population, leave no room for optimistic prognoses, some of which have managed to get into print (Egorov 1971).

BIOLOGY AND BEHAVIOR

Reproductive Biology

The arrival of the Siberian cranes on the nesting grounds takes place during the last 10 days of May, when the tundra is still mostly covered with snow (Perfiliev 1965). It coincides with the mass migrations of geese. Siberian cranes usually fly in pairs; also, less frequently, alone or in groups of 3. According to Perfiliev (1965), groups of 5-10 birds are sometimes seen, although this is exceptional.

The prenesting period is very short. Under most circumstances the places where nests are built are free of snow only at the beginning of June (1-4 June), yet complete clutches have been found in nests as early as 7, 10, 11 June (Perfiliev 1965, our data). The laying date depends on the climatic conditions of a given spring and can vary widely. Perfiliev found some eggs with fully formed embryos covered with down on 8 July 1962 (Perfiliev 1965); we found some in a similar state of development on 23 June 1972.

The incubation period of the Siberian crane is unknown, but judging by the length of incubation of

other large cranes (red-crowned, whooping [*G. americana*], white-naped), which is 30-35 days (Archibald 1973), we assume that these embryos were 23-24 days old. Thus, the dates on which the eggs, mentioned in the 2 examples above, were laid were 15-17 of June and 31 May-1 June, respectively, i.e., within a span of more than 2 weeks. The spring of 1972 was definitely unusually early. The finding of an unincubated clutch of eggs on 2 July (described by Vorobiev 1963) can be explained by the fact that the embryos were doubtless dead (possibly from cold). In such situations the hen nevertheless continues to sit on the nest for a long time (Perfiliev 1965). We can be sure that by the middle of July the chicks of even the latest laying have already hatched. The actual observance of the hatching of Siberian crane eggs has been recorded only once, 28-29 June 1960 (Vorobiev 1963).

Apparently, as is true of many other cranes, both chicks hatch but 1 of them almost invariably dies in the 1st days of life. In any event, both eggs are always fertilized (Perfiliev 1965, our data) but we always observed only 1 young chick with grown birds. At the wintering grounds in India, families of Siberian cranes are always made up of 2 adult birds and 1 juvenile (Hume 1868).

Choice of nest site, nest construction, clutch size, and dimensions and coloration of eggs have all been adequately described elsewhere (Vorobiev 1963, Perfiliev 1963, 1965). We mention only that the nesting territory of the Siberian crane is always located on the wide, more or less flat depressions near lakes that in spring are covered with melt water to a depth of 25-50 cm. The location of a nest directly on the shore of a lake or on an isthmus between 2 lakes, which K. A. Vorobiev and V. I. Perfiliev stress, is an incidental character.

It appears that a nest may be used for several years in succession, though not always (a pair may build a new nest every year). One of the nests we inspected was made of several distinct layers of water-soaked sedge, except for the top layer, which formed the actual nest and was made of completely dry stems and leaves. The sedge had been gathered by the birds in the immediate vicinity of the nest, and the places where this had been done was apparent immediately because the young shoots were consequently sprouting there more rapidly. Roshchevskii (1973) reported similar observations.

Both birds sit on the nest. Roshchevskii (1973) observed that when the "guard was changed" the relieving bird gave a distinctive bow, after which they exchanged places. We spent about 50 hours in the vicinity of 1 nest but never observed the parents exchanging incubation duties. We did not keep a constant watch on that nest, but each time that we looked at the nest the sitting bird turned out to be the hen (when we were sufficiently close we could easily distinguish her from her older mate by her 3-year plumage). However, the eggs in this nest were very close to hatching and possibly that is the reason for this atypical (for cranes) nest-sitting regime.

During that period we noted that the male followed a strict schedule: during the day he was absent and spent the time feeding beyond our view, but at night he was never more than 100-150 m from the nest. (We never managed to see him asleep.) Regardless of his absence during the day, when he was 2 km from the nest, he nevertheless kept visual contact with the sitting female. Without fail, whenever the hen left the nest he joined her within a minute or 2.

The hen sits on the nest in a somewhat flattened position and holds her head low, stretching her neck up only in alarm. She constantly turns her head to survey her surroundings. On the average of once every 2 hours she rises and turns the eggs. To sit back down on the nest she first hunkers down, then lowers her breast to cover the eggs with her fluffed-up plumage, and then finally sits down, folding her legs under her. At intervals of 1 hour she takes a quick nap (about 5 minutes or less), hiding her head in the feathers of her back. When a person appears within a radius of 2 km she quietly leaves the nest, sneaks away 100-150 m, and then silently flies off. If a person or a rider on a horse comes still closer, she remains at the 100- to 150-m distance and then demonstratively walks away, bending over slightly, and spreading her wings horizontally.

During the female's diversion demonstration the male copies her actions, though he performs them farther away from the nest. When flying with her near the nest he stays above and behind her. If a person appears suddenly near the nest, the bird sitting on it flies away with no diversionary behavior and stays away for a long time. Our observations showed, in short, that the Siberian crane behaves like other cranes when at its nest.

Sleep

We were able to observe sleeping cranes 3 times; once it was a single bird, the other 2 times the birds were territorial pairs. All 3 instances were at night, between the hours of 0300 and 0500. For a sleeping spot the crane chooses an open flooded place at least 100 m from the nearest knoll or clump of bushes. A sleeping crane stands on 1 leg, hiding the other in the belly feathers. The head is tucked under a wing from above, the neck lies flat to the body. Every 4 or 5 minutes the sleeping bird awakens, raises its head, and looks about, and then goes back to sleep. Sometimes on awakening a bird will stretch a wing out horizontally or make several motions with the free foot. The total duration of sleep, as best we could determine, is not longer than 2 hours. In 1 situation sleep was followed by feeding; in the 2 others by preening.

The sleeping that is done while standing on 1 leg with the head tucked under a wing is probably full, deep sleep. This is supplemented throughout the course of the day by frequent periods of sleep during which the crane stands motionless and does not assume the position characteristic of deep sleep. We observed birds doing this frequently and for extended periods at any time of day.

Feeding

As analyses of stomach contents have shown, the Siberian crane is omnivorous (Uspenskii 1961, Uspenskii et al. 1962, Vorobiev 1963, Perfiliev 1965). However, the principal part of its diet is plants, which Hume had determined at the Indian wintering grounds as long ago as 1868. On the tundra it feeds mainly on the roots, rhizomes, and sprouts of sedges, on bog cotton (*Eriophorum*), on grains, hellebore, and other plants, and shiksha berries. It also eats small rodents, insects, and occasionally fish. The crane has various methods of obtaining food. In flooded boggy low places it feeds intensively but for relatively short periods of time (each feeding session lasts about 15-20 minutes). During this time the bird hardly moves; it immerses its beak and head in the water, holding the beak to one side or in front of itself at almost a

right angle, and energetically uproots the underwater parts of plants; and then, raising its head, swallows them. The depth of water in which this takes place is about 25-30 cm.

The bird uses completely different tactics when feeding on dry hillocks or on the grassy tundra where mosses and sedge grow. Here the crane moves about in a leisurely, though determined, fashion for some distance, sometimes pausing for a moment and attentively inspecting the ground before continuing on its way. While feeding in this manner it probably gathers animal food (rodents and insects) and berries.

Crane Dances

The dances of the Siberian crane have been mentioned and described several times (Uspenskii et al. 1962, Perfiliev 1965). However, all these descriptions are taken from the accounts of "eyewitnesses," and there is every indication that they are improperly based on descriptions of dances by the common crane (*G. grus*), that is, the authors based their descriptions on an activity of a species that has been studied more. In actuality the "dances" of the Siberian crane are fairly unique.

Twice we were able to observe cranes "dancing." The 1st occasion was 16 June 1972 when we watched 1 bird about 2 years old from a distance of 100 m. The 2nd "dancer" was a male from a territorial pair; we observed him from about 800 m on 16 July 1973. From our observations we identified the following basic elements of the "dance" of the Siberian crane.

Leaps.--The bird does 3-4 high (2-3 m) leaps, upwards and a little to 1 side, assisting the leaps with strong flappings of the wings. During the leap the legs are directed to the side opposite the movement of the body. The bird usually does its leaps at the beginning of a dance but sometimes performs them between the following elements.

Bows.--The bird bends its head and neck forward and then flings them back several times, always increasing the amplitude of the swing and the tempo (Fig. 2A-C). Toward the end of the bowing the head and neck are thrown so far back that they almost touch the bird's back, and the bird bends down so low that its head goes between its legs. When bending down the bird raises its wings up. When flinging its head back it folds its wings and simultaneously raises its elbow joints and spreads out its primary feathers, thus forming a black spot to contrast with its white body.

Vocalization.--Suddenly the bird stands still, its plumage smoothed flat and its wings folded, its body stretched up almost vertically, and gives a short 2-syllable call (something like "Li-aaa...li-aaa...li-aaa"); the 1st syllable is slightly higher than the 2nd. When pronouncing the 1st syllable the birds points its beak straight up (Fig. 2D-E), even a little backwards. While pronouncing the 2nd, the bird abruptly drops its beak and looks forward and down.

The crane's "dances" are performed either in 1 place or while moving; both performances that we saw were in shallow water. The lone bird performed all the elements of its dance without moving; by adding swift steps to his dance, the territorial male described an elongated figure 8 about 20 to 30 m long. Meanwhile his hen stood, stretched up almost vertically (an attentive pose) about 10-15 m away. The sequence of dance elements in both instances was not repeated.

Our observations have shown that the "dancing" of the Siberian crane, like that of other cranes, has no direct connection with the reproductive cycle and is simply an expression of a bird's excitement. Apparently a bird will dance at any time and with any, or no, partner.

To compare the "dances" of the Siberian crane with those of other cranes we studied dozens of photographs and ethograms. Our analysis of this material has supported the opinion of Heinroth and Heinroth (1928) that, regardless of a certain similarity, the Siberian crane's "dances" are unique to that species and differ from the "dances" performed by the common, red-crowned, and other cranes. To be specific, the leaps are the only element similar in the dances of all members of the genus *Grus*. Other species include bows in their dances but those of the Siberian crane are very different. The farthest forward position is not known for other cranes and the farthest backward position is achieved only during "Unison Duets," that is, in a completely different situation. Judging from photographs (Walkinshaw 1973), even in Unison Calls the positions are not identical. Finally, and most significantly, the element which we have called "vocalization" is unique to *G. leucogeranus*.

The Siberian crane's "dances" also lack some of the elements characteristic of the common crane, such as the "parade step," the throwing into the air of grass and twigs, squatting on the heels, and ruffling the tertiaries (Schuster 1931, Moll 1957, Glutz von Blotzheim 1973). Unfortunately, we observed no threat poses. To have seen these is important to understanding the phylogenetic relationship.

Voice

According to some publications (Sudilovskais 1951, Perfiliev 1965) the Siberian crane's voice is similar to that of the common crane but is louder, more ringing, and more melodic. Heinroth and Heinroth (1928) and LaTouche (1933), in contrast, emphasize the dissimilarity of the voice of the Siberian crane and other cranes' voices. Pallas (1773) compared it to the call of a swan. (Pallas himself never saw a Siberian crane in the wild.) Walkinshaw (1973), who studied these cranes at their wintering grounds in India, also emphasizes the unusualness of the Siberian crane's voice and says that it is more musical but not loud and cannot be heard farther than 0.8-1.6 km away. Consequently, there is no consensus of opinion among the scientists mentioned.

After spending 4 field seasons in the Siberian crane's nesting area, we have concluded that the voice, like the dance, is very specific. The Siberian crane is a quiet bird when compared to other cranes. In particular, we never heard the "Unison Duet" (or "Unison Call"); this sound is typical of all other *Grus* cranes. It is performed usually in the morning and evening and also when exchanging places on the nest; it cannot be heard very far away. Roschkevskii (1973) also does not mention a "Unison Duet" and he observed cranes exchanging places on the nest. However, "Unison Duets" have been observed on the wintering grounds (Walkinshaw 1973).

The 2-syllable call of the Siberian crane, uttered during "dances," also has (as far as we can tell) no analogy in the vocal repertoire of other cranes. This call, repeated 4-6 times, is very quiet and cannot be heard more than 100-120 m if listening conditions are poor. Once when everything else was still we heard this call given by a bird on top of a hill about 800 m

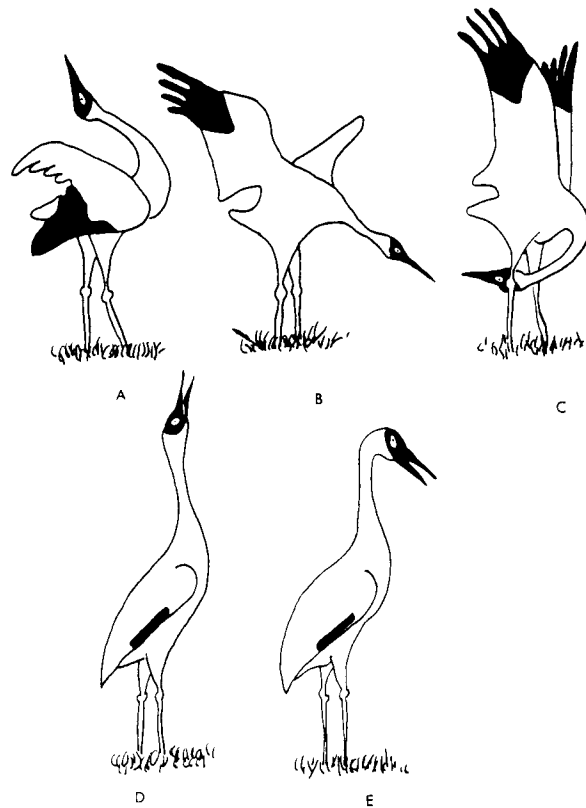


Fig. 2. Crane positions during a "dance": (A) throwing head and neck back, (B) intermediate position with wings half raised, and (C) final position of bow. Position of a crane's head during each call: (D) bill raised at onset of call and (E) bill lowered at end of call.

away. Besides that call, during all of our research we only heard the alarm signal. The alarm signal is given while the bird is in flight; it sounds like a subdued "krrroum," and much resembles the corresponding call of the common crane.

We assume that the quietness of the Siberian crane is not a coincidence. Visual communication seems more effective than auditory between members of a population widely scattered on a flat open plain when audibility is restricted by meteorological conditions. Indeed, when the crane shows the black feathers in its wings, moving next to the white plumage of its body (either while "dancing" or when flying), this catches the eye as a startling, unusual spot. On the other hand, in early summer when the tundra is still dotted with patches of snow, and ice still glitters on the lakes, a crane feeding quietly or sitting on a nest is almost unnoticeable.

Note that in other white-plumaged cranes (whooping, red-crowned) this reduction in sound communication has not been observed. It therefore indicates that the Siberian crane is more highly specialized and that it is especially adapted to life on the tundra. Other morphological features also attest to this adaptation. For example, the serrations on the beak are considered

an adaptation for pulling rhizomes and stalks out of frozen earth and other vegetarian cranes who do not inhabit tundra have no such serrations. The peculiarities of vocalization of the Siberian crane, in combination with specificity of the separate elements of its "dance," are evidence of the systematic specialization of this species within the Grus.

Molting

Contour feathers are shed throughout the summer. Whenever we saw birds at rest and busy preening, a large quantity of discarded feathers was visible. We often found feathers in the places where cranes customarily fed. The primary feathers are shed in July, but not by all birds simultaneously. Thus, during helicopter flights over the tundra 12-14 July 1973, we saw birds that were unable to fly and birds with noticeably new primaries who did fly. At that time there were also some birds who had not yet begun to shed primaries. The birds shedding most in this period were the 2-year-olds.

A Siberian crane without primaries cannot fly, but can run extremely fast, helping itself along with its wings in the manner of a molting goose. It is impossible to catch a crane running in this manner, whether you pursue it on horseback or in an all-terrain vehicle. However a helicopter can of course overtake a crane, and at this time, when most of them are molting, it would be possible to catch and tag most of the population.

DANGER FACING THE SIBERIAN CRANE IN YAKUTIA

Two main factors are having a negative effect on the population of the Siberian crane in Yakutia: the spring hunting season and the herding of domestic reindeer.

As we have already mentioned, cranes migrate with geese. During the spring migration almost all the men of the aboriginal population go goose hunting with decoys and spend much time in blinds along rivers. It is at this time that the low-flying cranes also perish in the rifle fire, usually with no evil intent on the part of the hunters. At any other time it is difficult to kill a crane even near its nest, and the local people no longer make any effort to hunt them on their nesting grounds.

Crane nests are often destroyed by herds of domesticated reindeer which are accompanied by herdsmen and dogs. Siberian cranes are very sensitive to disturbances, and even if the nest has not been destroyed by the reindeer or the dogs, the birds will not return to the nest for a long time if the herd is still in sight. In situations like this the eggs may soon be pecked apart by large gulls or by skuas. Sometimes frightened cranes never return to the nest. We know of an instance when a pair abandoned a nest on which they had been sitting for a long time, after some people approached the nest 3 times. Very likely this was the reason for the death of the clutch which Roschevskii (1973) found. The local people do not collect crane eggs and "use them in food" as Vorobiev (1963) and Perfiliev (1965) have written, because finding a crane nest is not an easy task. Indeed, not 1 of dozens of local people interviewed (hunters, reindeer herdsmen, fishermen) could distinguish a crane egg from a goose or gull egg. Nor do we have any evidence that cranes are ever used as food for dogs.

Fortunately the number of cranes destroyed within the nesting area is relatively small and probably the

few that die from unnatural causes do not exceed the seasonal growth of the population. Nevertheless, as the herds of reindeer grow, the threat to crane nests grows equally. Under modern conditions of the small crane population and low reproductive potential, reindeer herding poses the most serious and immediate threat. Without doubt, to establish a refuge or other restricted area for these birds between the Khroma, Lapcha, Gusinaya, and Berelyakh Rivers is the most realistic way to preserve the Yakut population. Equal measures of protection are urgently needed for this bird's wintering grounds.

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THE BIOLOGY OF THE SIBERIAN CRANE (STERKH) IN YAKUTIA

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In 1977, 1978, and 1979 the major portion of the Siberian crane (*Grus leucogeranus*) nesting habitat was aerially censused and nesting biology was studied. Eggs were collected and transported to the International Crane Foundation (USA) and to a Soviet rare species nursery in order to further the establishment of a captive population of this species. Aerial census routes encompassed all tundra subzones and the northern forest-tundra from the north bank of the Khroma River to the Alazea River.

CENSUS METHODS

Aerial census using planes and, at times, helicopters was carried out to determine the Siberian crane population. The flight altitude was 100-120 m and the air speed 150 km/h. The birds were counted by 2-4 census workers along a 2-km-wide transect (1 km/side). Results were transferred to a map. Data concerning numerical, social, and age characteristics of the birds were recorded in a field journal; the habitats were briefly described.

During the 1st stage of work, counts were made on linear, previously plotted courses that covered the territory as uniformly as possible. However, the use of formal transects was ineffective for censusing such a stenotopic, rare species. Therefore, after reconnaissance flights the search was directed towards territorial pairs of Siberian cranes. Aerial census flight lines allowed for the biotopic coincidence of nesting territory. Aerial investigation was carried out for 3 years during the 2nd half of the brood period. Counts were made from 15 June through 1 July 1977 covering an aerial distance of 4,600 km, over 1,500 km between 22 and 29 July 1978, and 1,100 km on 18 July 1979; total distance of transects exceeded 7,200 km.

POPULATION

The spring-summer climatic conditions of 1977 closely approximated the average over many years. By early June the tundra was practically void of snow, small lakes had thawed, and ice had disappeared from most of the larger lakes by 20 June. During the aerial censusing we found 40 nests and territorial pairs of cranes (Fig. 1). We also saw 16 non-nesting cranes (7 singles and groups of 2, 3, and 4 individuals). Three of the non-nesting birds were yearlings.

The spring of 1978 was very late and cold. The low temperatures and unusually heavy winter snowfall delayed thaw on the tundra. By mid-June no more than 50% of the area of low-lying, polygonal tundra had thawed. This had a negative impact on the crane population. Along aerial routes, which overflew 33 nesting territories mapped the year before, 13 nesting (territorial) pairs of cranes were discovered. However, only 5 pairs were located at the previous year's nest sites. Pairs and lone Siberian cranes still stayed near 1-year-old nests, but their behavior clearly indicated that they had not begun nesting. On 29 June, 3 Siberian cranes were encountered--2 adults and a yearling. Apparently, this was a family with a year-old fledgling (who had not yet separated from the parents which had no opportunity to nest).

The 1979 nesting season, just like the previous 1, proved to be unfavorable. There had been little snow that winter and it began to melt very early. However, overall low temperatures for the 2nd half of May and early June, accompanied by frequent freezes and snowfalls lasting until the end of June, slowed the thawing process. By 18 June, 25 to 50% of the extensive area northwest of Chokudrih and along the left bank of the Khroma River, which in former years had been inhabited by Siberian cranes, was still covered by snow. Twenty-two nesting sectors, known from previous years, were examined during the census. Ten nests were discovered; only 3 were located on previous sites. Among the 5 lone birds sighted, 3 were staying close to the old nest sites.

Based on aerial census results over the 3-year period, a judgment may be made concerning the total number of Siberian cranes in the Yakutia population. Methods described in detail by Flint and Kistchinski (this publication) were used to estimate the total population. Taking as a basis the data from the optimum year 1977, and keeping in mind that peripheral sections of the area had not been counted and that a portion of the birds summer beyond the borders of the nesting area, we estimate the total Siberian crane population to be no greater than 250-300 individuals. The latter estimate confirms the earlier value estimate of Flint and Kistchinski (this publication) derived from a limited data base and varies only slightly from the estimate of Vshivtsev et al. (1979).

ZONAL DISTRIBUTION

All of the Siberian cranes noticed during the counts were within the tundra zone. Nests were in the typical subzone and southern shrub tundra. Climatic conditions during the prenesting period undoubtedly determine basic intrazonal redistribution of nesting territories for various years. As the data indicate, during the cold years of 1978 and 1979 the northern territories remained uninhabited. A portion of the cranes from these territories then apparently occupied new territories situated more to the south. Another portion of the population simply does not nest. In this respect 1979 is particularly informative when, against a background of a low population of breeding cranes, we observed an especially strong shift to the south. At least 3 nests, discovered at the forest tundra border, were newly constructed that year. Thus, there is some indication that in unfavorable years a small number of Siberian cranes nest in the northern forest tundra, settling among its extensive depressions.

An observer can arbitrarily distinguish 3 zones within the Siberian cranes' nesting area: an annually inhabited zone in which the cranes attempt to nest even during unfavorable years, and 2 irregularly inhabited zones situated north and south of the regular nesting zone. During warmer springs the cranes use the northern territories but they move south during colder years.

A large part of the Yakutia sterkh population nests in the tundra between the Yana and Indigirka Rivers.

A physical-geographical feature of the Yana-Indigirka Region is the precise delineation of 3 distinct aggregates of sterkh nesting territories. The 1st is located on the north bank of the Khroma River south of Lake Soluntaakh and encompasses an extensive low-lying plain. In 1977 almost 50% of all known nests and territorial pairs were located in the latter section. The 2nd nesting aggregate was located 30-60 km northwest of Chokurdakh in a system of large lakes. In 1977, 25% of the pairs counted were noticed there.

The 3rd aggregate is 30-40 km south of the 1st 2 and north of the settlement of Berelyakh. Although relatively few cranes nest at the latter site (in 1977 there were 6 pairs or 15% of the population), this group is the most stable in occupying its territory. In the cold year of 1979 only 2 nests were discovered on the north bank of the Khroma River instead of the 18 in 1979. None of the 10 nest sites was reoccupied in the 2nd aggregate. There is reason to believe that in a system of large lakes there sometimes occurs an anomalous, particularly severe, mesoclimate, brought on by the extreme cooling action of huge masses of slowly thawing ice. In the 3rd population aggregate the number of nesting Siberian cranes, in bad years, has decreased by only 30-50%.

TERRAIN OF NESTING TERRITORIES

Analysis of the terrain of 46 nesting territories of Siberian cranes allows us to ascertain that they coincide with tidal flats--flat, swampy, grassy depressions, primarily of lake origin. Siberian cranes inhabit them in different ways depending on the size and degree of wetness of the appropriate section. The overwhelming majority of nests were placed among spacious tidal flats, whose linear dimensions exceeded 2 km. The large size of a tidal flat, which does not obstruct the cranes' view, has great significance for defense. This is particularly important for a bird sitting on a nest, who, although remaining inconspicuous, can still be in control of the situation from considerable distance.

The preferred habitat was a damp tidal flat with well-developed vegetative cover made up of typical polygonal swamp associations of hydrophilous sedge and cotton grass that form sparse, short stands. The dynamics of biotopic distribution of nesting territories, based on observations over 3 years, are expressed in Table 1.

The numbers of Siberian cranes nesting on the dry sections of hilly, polygonal tundra increased in 1978 and 1979 as a result of late snow thaws in the optimal biotopes. We were able to examine 3 new nests constructed in such atypical sites. These nests differed by being very thin, only 2-3 cm thick in the central part of the nest; the outer diameter of the nests was no more than 35-40 cm. In comparison, most typical nests have a diameter of 90-130 cm and a central thickness of 15-20 cm (up to 45 cm).

TERRITORIALITY

The average shortest distances between territorial pairs of Siberian cranes fluctuated, in various years, from 14 to 20 km (absolute distances varied from 2.5 to 75 km). Data over 3 seasons show an average of 1 territorial pair in about 290 km². Pairs occupy only a small part of the suitable nesting biotopes within the total nesting area. This disparity between potential capacity and the present numbers of birds has resulted in an almost complete lack of territorial

competition. The reasons for this lack are not entirely clear. It is possible that reserves of potential nesting territories should be viewed as one of the requisite conditions for the existence of the species in the subarctic's cruel, unstable environment.

During the census of 1978, 5 nests (37%) were situated at the same site as the previous year and birds without mates remained close to 10 other previously used nesting sites. Thus, Siberian cranes have been noticed in 45% of the nesting territories known since the 1977 census.

In 1979 more than 30% of the nests counted were at old sites. Nests at identical sites near Lake Biugiucheyen and Kieng-Kiuel (20-30 km north of the Berelyakh settlement) were recorded 3 years in sequence. In 1972 and 1973 we noted cranes nesting on the Lake Biugiucheyen tidal flat. It is possible that over the 8-year period (1972-1979) the nesting territory has been occupied by the same pair. In 1972, 1 nest was

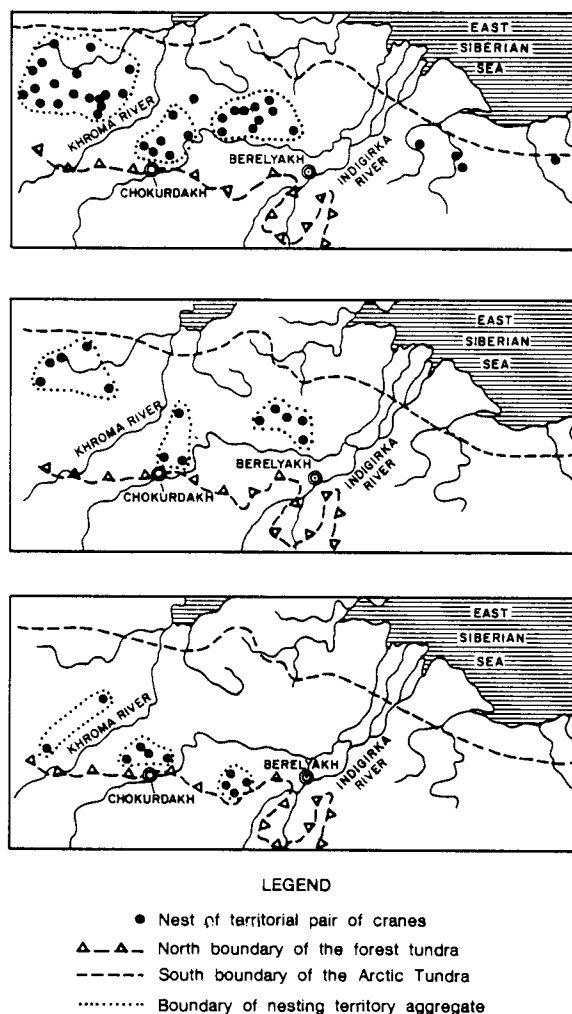


Fig. 1. Location of nests and territorial pairs of Siberian cranes in the main part of the nesting range.

Table 1. Biotopic distribution of Siberian crane nesting territories.

Biotype	1977		1978		1979		Average	
	Nests	%	Nests	%	Nests	%	Nests	%
Very low tidal flat with water mirrors	2	10	2	13	1	10	5	11
Damp tidal flat with noticeable polygons	14	70	8	50	7	70	29	63
Drained tidal flat with very expressed polygons	4	20	2	12	1	10	7	15
Dry, hill, polygonal tundra	--	--	4	25	1	10	5	11

discovered at Adyagir Summit (10 km northwest of Lake Biugiucheyen). In 1973-1975 we did not visit this region but cranes were still nesting there in 1976 and 1977. During the 1st half of the nesting period in 1978 only 1 bird was around the nest, its partner apparently dead. The nest plot, however, remained occupied. In 1979 birds were no longer present. While nesting within a territory for several successive years, the sterkh frequently uses the same nest, annually refurbishing the nest. Sometimes they build new nests, either in the immediate vicinity or at considerable distance. In 1977 the nest at Adyagir Summit had been built 3 km from the old nest; in 1979 a nest with 1 egg was discovered only 2 m from the old nest.

NESTING PERIOD

During work related to collecting eggs for hatcheries, we have recorded precise data for the hatching of 17 nestlings. Six chicks hatched from 26 June to 11 July of 1977. In 1978, 6 fledglings hatched between 28 June and 14 July. In 1979, 5 chicks hatched between 26 June and 5 July. When the eggs were collected some cranes already had chicks, thus, we were collecting only eggs from a later laying. We believe that the 1st eggs hatched between 20-25 June. The majority of chicks appeared during the last 5 days of June and the 1st 5 days of July. In a few instances eggs hatched as late as the middle of July.

Several observations allow us to postulate that the incubation period of the Siberian cranes is somewhat shorter than for other large cranes, totaling about 27 days. The beginning of egg-laying in the population is not simultaneous and is stretched out over 2 weeks from late May to mid-June. A majority of the birds lay their eggs during the 1st week of June.

The extended nesting period, in our opinion, is a result of substantial differences in the climatic conditions in various regions of the nesting range. The earliest hatching dates over a 3-year period were noted in the southern "Bereyakh" nesting aggregate; the latest laying period occurred in the large lakes region northwest of the Chokurdakh settlement. Even though climatic conditions varied in the 3 spring seasons described, the timing of nesting remained the same. Pairs do not nest if conditions are unsuitable during the optimum 2-week period.

SOCIAL STRUCTURE

During the 3 field seasons 157 Siberian cranes were counted; among these 63 (77%) were territorial pairs.

However, aerial observation does not provide accurate information about the percentage of territorial pairs that actually nest. This is a complex problem whose solution is still pending. According to data of Flint and Kistchinski (this publication), about 60% of the territorial pairs or 40% of the entire population actually nests. Based on this data, and accepting 300 as a close approximation of the population, we estimate there are 60 nesting pairs.

The sterkh has, as do other species of cranes, an innate nesting conservatism (see Flint and Kistchinski, this publication). The average number of eggs per nest (from a sample of 12 nests) is 1.75. Thus, 105 eggs are laid annually among the Yakutia population.

We analyzed the fate of 21 eggs (including those transmitted to the U.S.) to determine the actual fertility of the population and the nest mortality. Four of the eggs were not fertilized and 2 (from different layings in different years) contained dead embryos at various stages of development (both eggs had been broken from the outside at the equatorial locus). In 3 additional eggs the embryos were defective and would not have hatched without man's help. In the wild they would have been doomed. Thus, only 12 of the 21 eggs were complete. Among these 12, 10 were from layings of 2 eggs each. However, it is known that in such circumstances, even when both chicks hatch normally, the weaker perishes as a result of the unusual mutual aggressiveness of the newborn. The weaker ultimately expires before fledging.

Thus, from 5 layings only 5 chicks have a chance of survival and from 21 eggs in the wild, only 7 chicks have a chance, i.e., nest mortality of 67%. Thus, of the 105 eggs laid in the population each year, only about 30 chicks can survive (10% of the total population of 300 birds). This figure may even be somewhat inflated, rather than too low, because it is possible that the percent of nesting among territorial pairs is lower than we have estimated.

Some of the birds undoubtedly die between hatching and fledging (or even later); therefore, the true population increase of the Yakutia Siberian crane is probably lower than 10%; that is, the sterkh population of Yakutia probably cannot reproduce itself.

LIMITING FACTORS WITHIN THE NESTING RANGE

It is usually accepted that the Yakutia Siberian crane population does not encounter significant nega-

tive influences during the nesting season. We agree with this hypothesis in general. However, besides well-known limiting factors caused by man's activities, others are found in nature. Among the natural factors are wild reindeer. During migration huge numbers of reindeer cross the Siberian cranes' habitat. In normal years practically all of the reindeer have moved to the coastal arctic tundra before the nesting season begins. But in years with a late spring, like 1978 and 1979, intensive migration activity of reindeer has been observed through mid-June (when the 1st fledglings appear).

We have twice observed the reaction of a pair of cranes to reindeer crossing their nesting territory. The male began to display obvious signs of distress before the female sitting on the nest. As the reindeer came within 1-1.5 km he flew out to meet them and landed near the herd. The female, in 1 instance when the reindeer skirted her at a distance of no less than 1 km, remained on the nest. In the 2nd instance, when a herd of 6 bucks moved directly toward the nest, she got up and walked off to the side at a distance of about 300-500 m from the deer. During mass migrations of reindeer similar situations can occur several times

a day. The probability of direct danger to the cranes' eggs from the reindeer is quite small. However, a crane's absence from its nest provides excellent opportunities for predation for skua, glaucous gulls, and herring gulls. In 1978 and 1979 there were almost no lemmings in the tundra; therefore, the eggs of various birds became a substantial part of raptors' diets.

The combination of unfavorable climatic conditions, a late reindeer migration, and heightened pressure from skua and other large gulls due to a depressed lemming population, has probably had a serious negative impact on the nesting success of the sterkh population.

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Introducing the Cranes



Demoiselle crane (photo by D. Hruskova).

ENDANGERED CRANES

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The beauty, size, and illusive nature of the whooping crane (*Grus americana*, Fig. 1) made it a challenging target for white colonists in North America and, as the crane population declined, the value of their eggs increased to oologists. By 1941 only 15 migratory whoopers survived, and in 1949 the nonmigratory group (6 survived in 1941) in Louisiana became extinct. The magnificent Siberian cranes (*Buggeranus leucogeranus*, Fig. 2) that breed on the Soviet tundras and winter in countries south of the USSR are still hunted in Afghanistan; that group now numbers fewer than 40 birds, although perhaps 300 survive in east Asia. The treasured and regal red-crowned cranes (*G. japonensis*, Fig. 3) of temperate east Asia benefit from protection in eastern USSR and the Orient, but the wetlands on which their productivity depends are being reclaimed by mankind, whose numbers continue to soar while the cranes may number fewer than 1,000.

Among the 15 species of Gruidae, the 3 white species--whooping, Siberian, and red-crowned cranes--are reduced to numbers so low that they may be lost unless intensive conservation programs are continued and expanded. Three other species, the hooded (*G. monacha*, Fig. 4), white-naped (*G. vipio*, Fig. 5), and black-necked (*G. nigricollis*, Fig. 6) cranes number in the low thousands and their populations appear stable. The hooded and the white-naped cranes are increasing. The wattled crane (*B. carunculatus*, Fig. 7) population numbers in the low thousands in south-central Africa but is rapidly declining. Information is not available on the northern population of wattled cranes in Ethiopia. The 8 remaining species continue to thrive, although several subspecies and suspected subspecies are in jeopardy, in particular the demoiselle cranes (*Anthropoides virgo*, Fig. 8) of northwest Africa, the Mississippi (*G. canadensis pulla*) and Cuban sandhill cranes (*G. c. nesiototes*, Fig. 9), and the eastern sarus (*G. antigone sharpii*, Fig. 10).

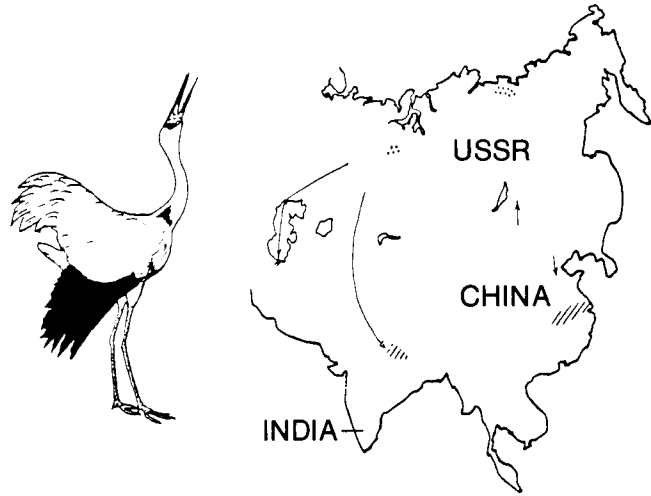


Fig. 2. Distribution and migration routes of the Siberian crane.

Fortunately, no crane species has been lost to date; however, the ever increasing pressure from human populations, particularly in tropical and subtropical countries, presents many problems for these large space-demanding birds that require shallow wetland habitats for nesting. To better face these current and future problems, a review of the history of crane conservation is pertinent, followed by a discussion of possible future programs that will assure the survival of all 28 probable crane forms (species, subspecies, probable subspecies).

CONSERVATION PROGRAMS IN RETROSPECT

The world's tallest flying bird is the Indian subspecies of the sarus crane (*G. antigone antigone*);

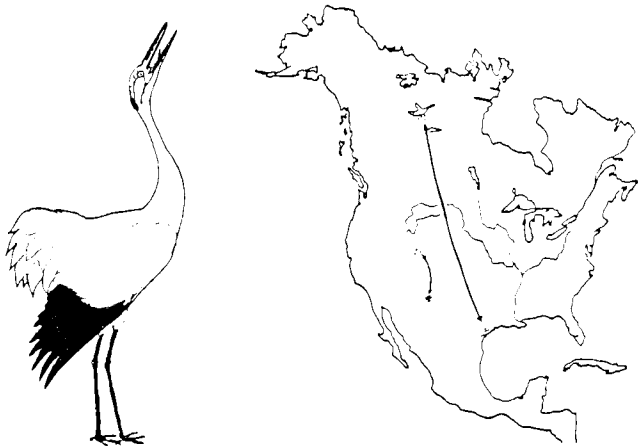


Fig. 1. Distribution and migration routes of the whooping crane in North America. (Sketches in Figs. 1-13 are by Diane Pierce; dots indicate breeding areas, lines indicate wintering areas, arrows indicate migration routes, dots with lines indicate a sedentary population.

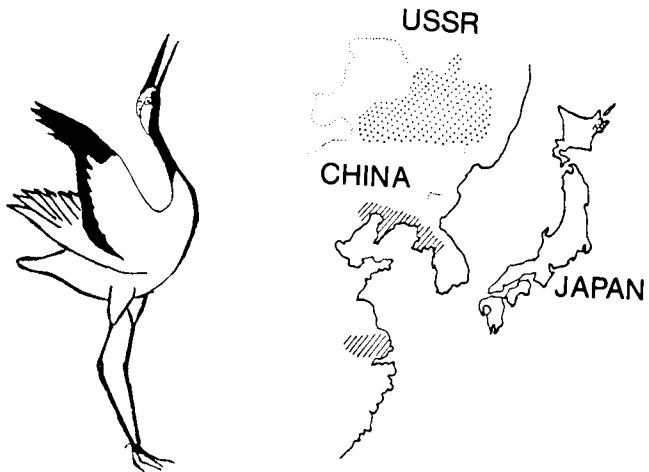


Fig. 3. Distribution of the red-crowned crane.

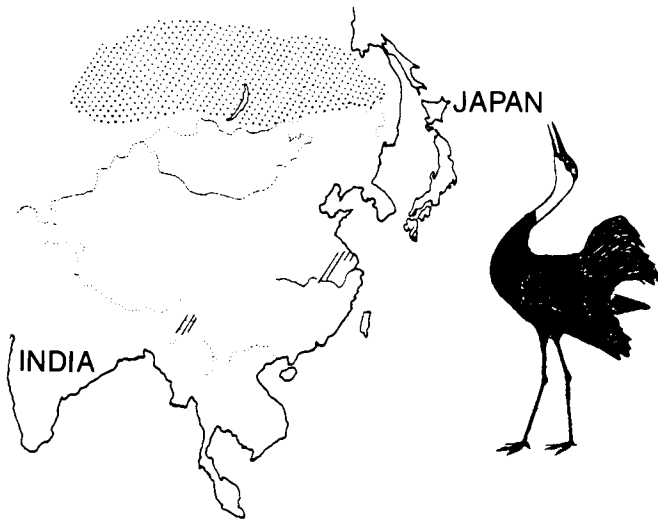


Fig. 4. Distribution of the hooded crane.

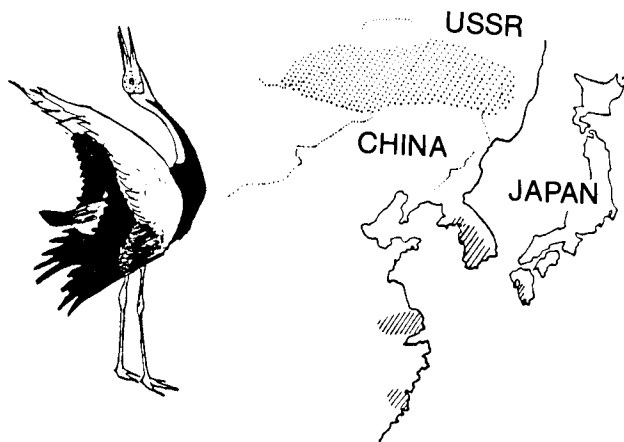


Fig. 5. Distribution of the white-naped crane.

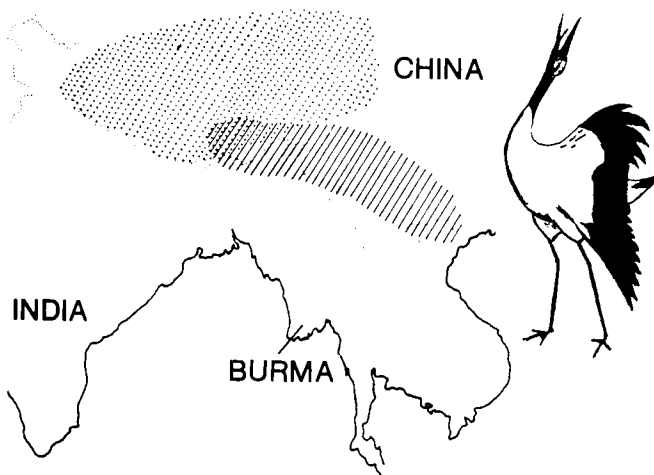


Fig. 6. Distribution of the black-necked crane.

males are in excess of 1.6 m in height and weigh as much as 12 kg. Found across the northern lowlands of the subcontinent in sympatry with some of the world's densest concentrations of humanity, the sarus ironically thrives in harmony with man and a landscape that has been transformed by human activity. Fortunately, since the early days of Hinduism, the Indians have considered the sarus as sacred birds that bring good luck. The species is strictly protected. The cranes have lost their fear of man and adapted to nesting in small artificial or seasonal wetlands near man. They prosper among the millions of farmers of northern India, demonstrating that if man protects and respects, some species of cranes can coadapt if their basic habitat needs are provided.

The Indian sarus are as adaptable as the ubiquitous common cranes (*G. grus*, Fig. 11) and demoiselle cranes that winter in India. Unfortunately, the Siberian crane, which also winters in India, is a specialized aquatic vegetarian and apparently is unable to move into an upland feeding niche in winter, as do the sarus, common, and demoiselle cranes. Siberian cranes have declined despite protection, as the wetlands of northern India are reclaimed for agriculture.

Black-necked cranes nesting on the Tibetan Plateau and demoiselle cranes breeding across the semidesert steppes of Mongolia also benefit from protection. They prosper and can be as closely approached as Florida sandhill crane (*G. c. pratensis*) pairs, which have recently been reported nesting on small wetlands surrounded by a golf course. Popular concern for the welfare of the cranes is perhaps the most basic and important ingredient in any conservation program, a consideration the late Robert Porter Allen certainly recognized when for long months he campaigned for whooping crane conservation to people living along the whoopers' 4,000-km migration corridor through the center of North America (Allen 1952). Allen's unparalleled efforts bloomed into local and international concern for the whoopers, and the magnificent white cranes have slowly withdrawn from the brink of extinction. The traditional migratory population now numbers 76 birds.

Legal protection of the cranes is important. Law enforcement is imperative in certain countries and, unless local attitudes favor the birds, the cranes can disappear quickly as a law is changed or not enforced. For example, for centuries cranes were strictly protected by the ruling classes of Japan, and the white-

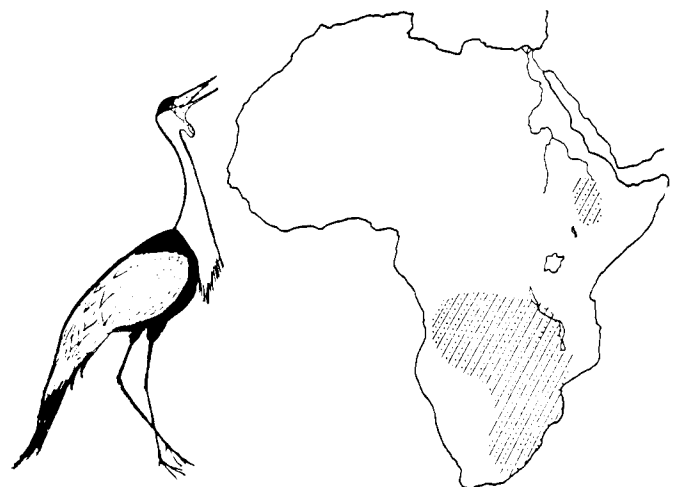


Fig. 7. Distribution of the wattled crane in Africa.

naped and hooded cranes flourished on the wintering grounds in Japan along with the stately red-crowned cranes that nested and wintered there. Crane hunting was allowed during the Meiji Era in 1877. The birds were slaughtered and their habitats developed.

The cranes were again protected by Hokkaido prefectural law in 1890. The red-crowned cranes were considered extirpated until 1925, when Mr. Haruji Saito found a small group surviving on the great wetlands of east Hokkaido near Kushiro. Fortunately, an ancient people, the Ainu, near Kushiro considered the crane "God of the Marsh." A relict population of Ainu survived and so did their precious cranes in that remote corner of Japan. In 1952 the local people started to feed grain to the cranes in winter, a tradition that has been continued to date. The cranes increased from perhaps 30 birds in 1952 to about 250 today.

The white-naped and hooded cranes also suffered in post-Meiji decades. By the time artificial feeding stations were established for them in Kagoshima, Kyushu, Yamaguchi, and Honshu in 1952, there were only about 45 white-naped cranes and 300 hoodeds. Continued feeding and protection have substantially contributed to their increases to more than 1000 white-naped and more than 4000 hooded cranes. Now ornithologists are worried about the enormous concentration of almost 5,000 cranes at the rice paddy feeding station near Arasaki in Kyushu, particularly because farmers increasingly complain of crop damage from the cranes.

A die-off is feared as the crane numbers increase on that small plot of land that under natural conditions would be frequented only by several pairs on defended feeding territories. If winter feeding is discontinued, crop damage will increase and tourists will be disappointed if they cannot see the crane flock at Arasaki. If feeding continues at a restricted site, the population will probably be reduced by

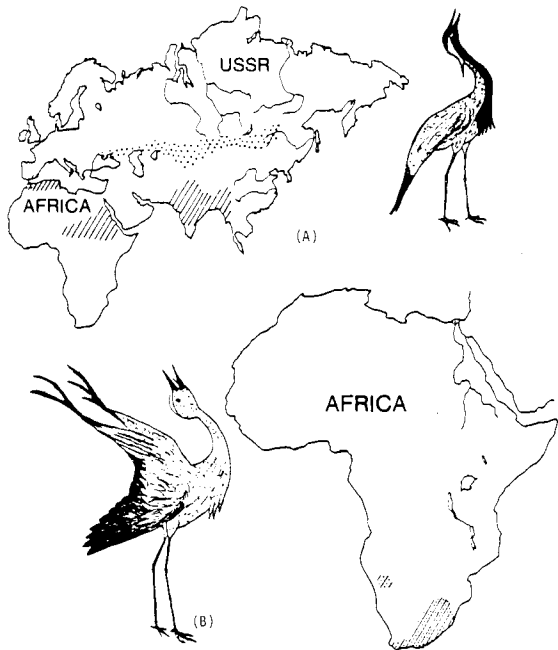


Fig. 8. Distribution of the demoiselle (A) and Stanley (B) crane.



Fig. 9. Distribution and migration routes of the sandhill crane in North America, Cuba, and USSR. The Cuban, Mississippi, and Florida subspecies are sedentary populations at those respective locations.

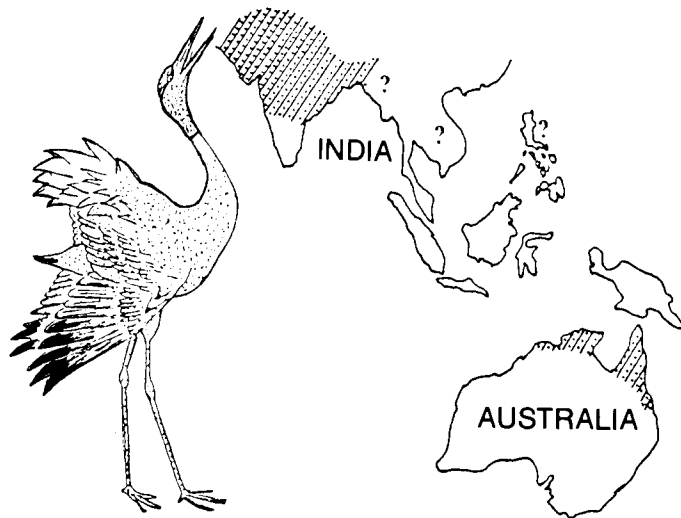


Fig. 10. Distribution of the sarus crane.

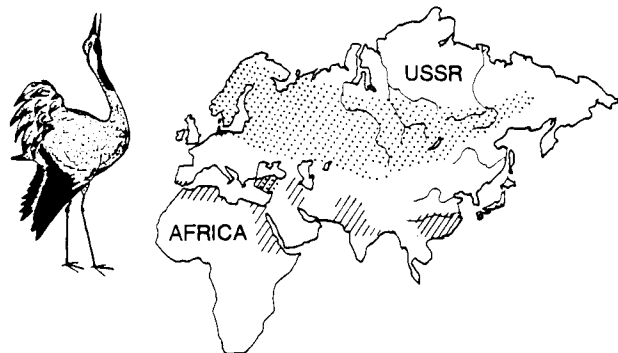


Fig. 11. Distribution of the common crane.

disease. Paradoxically, a conservation measure represented by artificial feeding now poses a serious threat to the survival of the flock that contains the majority of all hooded cranes known to survive. Any management program for cranes obviously must be based on sound biological principles to prevent the Araski-like problems.

Innovative programs have been undertaken in West Germany to improve and to enlarge the breeding habitat for common cranes, which, although numerous in east Europe and across Asia, were extirpated from the British Isles in medieval days (Armstrong 1979), later in France, and today as few as 22 pairs survive as summer residents in West Germany. Conservationists have been purchasing available wetland and establishing a satellite network of crane sanctuaries. Trees bordering the wetland are cut to provide the open habitat that cranes prefer. Small ponds have been excavated and islands developed on which the cranes nest. Several pairs have even nested on styrofoam islands that are capped with marshland sod and vegetation. Thus, man is aiding the common crane make a comeback in a heavily populated European country, an activity that in many ways parallels man's concern for the resident sarus cranes in India.

While the Germans are reviving a relict group of common cranes, researchers in Canada and the U.S. are cooperatively making great strides in establishing a second migratory population of whooping cranes, using the greater sandhill crane (*G. c. tabida*) of Idaho as a foster-parent species. Fertile whooping crane eggs have been transferred from the wild whooping crane nests in subarctic Canada, and from nests of captive whooping cranes at the Patuxent Wildlife Research Center in Maryland, USA, to Grays Lake National Wildlife Refuge in Idaho. One whooping crane egg is substituted for a single egg in sandhill crane nests of pairs that are known to be steady, reliable parents. Fifteen beautiful whooping cranes are now established in the Rocky Mountains and are migrating between Idaho and New Mexico in autumn and spring despite initial problems with drought and predation from coyotes. These sandhill-reared whooping cranes do not appear to be imprinted on sandhill cranes and are demonstrating an instinctive ability to recognize and to want to flock with conspecifics. Sandhill-reared whooping cranes have not paired, but project manager Dr. Rod Drewein believes it is now a matter of increasing the population to assure that potential mates will meet in the great expanse of nesting habitat of the northern Rocky Mountains.

But the whooping crane is not the rarest crane form. With the possible exception of demoiselle cranes breeding near Rez, Morocco, on the Atlas Plateau, the rarest and most endangered crane is probably the Mississippi sandhill crane of Jackson County, Mississippi, USA. Fewer than 50 Mississippi sandhills survive. Several years ago their last breeding habitat was threatened by the construction of a super highway, a project that created such a controversy between conservationists and developers that the issue went before the Federal Supreme Court (Valentine 1979). The cranes won.

Traditional and new human values, protective legislation against hunting, law enforcement, winter feeding programs, breeding habitat enhancement programs, and restocking programs are all helping to ensure the survival of certain populations of wild cranes for future generations to appreciate. However, other cranes are rapidly declining and, because of local and political problems, conservation programs may not be

available in time to prevent their demise. Even the cranes that are now recovering are still in perilously low numbers. A November conflict along the Korean Demilitarized Zone (DMZ) might obliterate most of the white-naped cranes that winter in the Republic of Korea, along with those that migrate through Korea to winter in Japan. An outbreak of crane Herpes virus at Arasaki, Japan, in winter could destroy half of the world's known population of white-naped cranes, and practically all of the hooded cranes. Changes in local attitudes towards wildlife with the wane of Buddhism across the Tibetan Plateau might lead to the demise of the black-necked cranes (see article by Archibald and Oesting in this publication).

As a countermeasure to these threats, efforts are being made to establish "Species Banks" of endangered cranes in captivity in China, Japan, USA, USSR, and West Germany. These efforts are based on the pioneering captive propagation work by Dr. Tadamichi Koga and his colleagues at Ueno Zoo, Tokyo, in the 1950's (Koga 1976) and innovative research by biologists at the Patuxent Wildlife Research Center, USA, in their unparalleled efforts to breed whooping cranes (Erickson 1975). In 1972 the New York Zoological Society began a propagation program for white-naped and hooded cranes at the Bronx Zoo and, in recent years together with the Noble Foundation, a center is being developed for the management of warm-climate cranes on St. Catherine's Island off the coast of Georgia, USA.

In 1973 the International Crane Foundation incorporated in Wisconsin, USA, as a public, charitable, non-profit organization dedicated to the preservation of all species of cranes. The Conservation Research Center of the National Zoo of the Smithsonian Institution recently constructed extensive enclosures for maintaining and breeding rare cranes near Front Royal, Virginia. A large crane breeding complex has been constructed and stocked at the fabulous Vogelpark Walsrode, West Germany, and ICF is incorporating an ICF-Germany at the Vogelpark. The Ministry of Agriculture of the USSR established a crane breeding unit at the Okskiy State Preserve southeast of Moscow, where efforts will concentrate on the Siberian crane, a species that nests exclusively in the USSR and is clearly the most threatened of crane species.

In northeast China a 30,000-ha wetland near Jalung has been protected as a special reserve for red-crowned cranes. Along with some 120 wild cranes in the reserve, about 30 cranes are maintained in captivity in a semiwild condition on the edge of the Jalung wetland. In Hokkaido, Japan, an elaborate propagation center has been constructed beside the Kushiro Zoo, near the wetlands that support some of the resident red-crowned cranes. Not far from the Kushiro Zoo crane-breeding center, a devoted crane conservationist, Mr. Ryoji Takahashi administers a crane park where several pairs of red-crowned cranes breed. These birds are used throughout the year for public education.

THE CONSERVATION GAPS

The above account might lead the reader to believe that all is well with the Gruidae. However, consider the increase in human numbers, the ever-increasing need to convert remaining wetlands to man's use, and the turmoil between nations over whose tense boundaries the cranes gracefully migrate. We solemnly face the bleak realities confronting these space-demanding birds that have graced earth's wetlands some 60 million years and that, in several instances, are now reduced to dozens.

The genus *Bugeranus*, containing the Siberian crane of Asia and the wattled crane of Africa, is acutely endangered. These species are specialized aquatic vegetarians that excavate sedge tubers from shallow water. Unlike some of their more successful cousins among *Grus*, *Bugeranus* do not readily move into agricultural fields during the nonbreeding periods. They depend on great expanses of shallow freshwater habitat throughout the year, a trait that has been responsible for their decline while sympatric but adaptable crane species have simultaneously increased their populations. To make matters worse, whereas the Balearica crowned crane (Fig. 12) pair often rears 2 or 3 chicks, and *Anthropoides* and most *Grus* species not infrequently rear 2 chicks per breeding attempt, Siberian crane chicks demonstrate unparalleled intersibling aggression. A pair of Siberian cranes has never been known to rear both chicks. The wattled cranes, likewise, have low productivity, undoubtedly partly due to their tendency not to breed unless water conditions are ideal, and to their single egg clutches.

Two relict populations of Siberian cranes survive with perhaps fewer than 340 birds in the wild and just 14 in captivity. The western group breeds on Soviet tundras near the lower reaches of the Ob River. In autumn they seem to diverge into a group of perhaps 12 birds that winters on a duck-trapping compound near Feredunkenar on the Caspian Lowlands of Iran. A second group migrates past the Aral Sea, over the Hindu Kush Mountains of Afghanistan then down to the northern plains of India, where they winter at the famed Keoladeo Ghana Bird Sanctuary near Bharatpur, about 180 km south of New Delhi. En route they rest at Lake Ab-i-Estada, Afghanistan, but, unfortunately, they are hunted there, a factor that may have contributed to a decline from 76 birds in 1972 to just 33 cranes this past winter. In 1979 the breeding ground was discovered and we hope that eggs will be collected and hatched in captivity at the Okskiy State Preserve or elsewhere before the western population of Siberian Cranes is extirpated.

In eastern Siberia a more substantial group of Siberian cranes breeds in tundra between the Indigirka and Lena Rivers, a group that has been studied intensively by Vladimir Flint and colleagues over the past decade. These cranes are presumed to winter somewhere on the Yangtze River Basin in China; however, the Chinese have not located the cranes, although surveys have been conducted the past 2 winters. If the wetlands of the Siberian cranes are drained and developed in China, the species may be lost because more than 90% of all Siberian cranes depend on China's wetlands in winter.

The specialized winter habitats of the Siberian crane approximate the year-round haunts of the wattled cranes in Africa. Populations of the latter species are declining sharply over much of central and south Africa as the wetlands are altered by draining and damming and as the cranes are disturbed by fishermen and assorted anthropogenic factors. Little is known about the status of the northern population in Ethiopia, but probably they face the same threats that are reducing the southern population in Zambia, Botswana, and South Africa.

Other than the whooping crane and the red-crowned crane, whose numbers are perilously low but perhaps stable and recovering, and the *Bugeranus* species that are in jeopardy, all other full species are prospering, although the white-naped, hooded, and black-necked cranes warrant special monitoring because they number in the low thousands. As mentioned above, how-

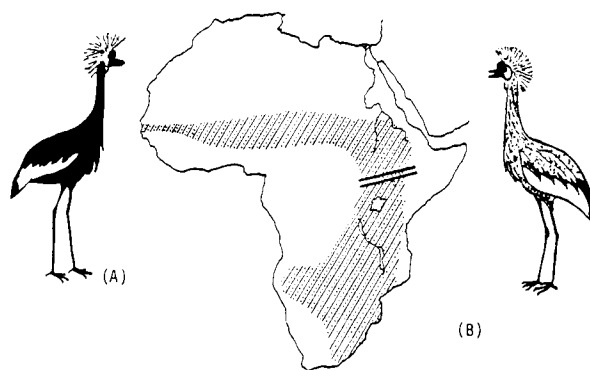


Fig. 12. Distribution of the black-crowned (A) and gray-crowned (B) cranes in Africa.

ever, several subspecies or suspected subspecies warrant urgent conservation action.

Demoiselle cranes used to breed on the Iberian Peninsula and across the Atlas Plateau of northwest Africa. It now appears that demoiselles have been extirpated from Europe, Tunisia, and Algeria. Encouragingly, the International Waterfowl Research Bureau's network of bird watchers discovered a small group of perhaps 6 cranes apparently breeding near Rez, Morocco. Attempts will be made in the near future to study these cranes and define their problems; conservation programs can be developed from such information.

As already outlined, the Indian sarus crane thrives as a consequence of Hinduism; however, the smaller and darker eastern sarus of Southeast Asia is considered almost if not totally extirpated from Burma, Thailand, and the Philippines and of undetermined status in Laos, Cambodia, and Vietnam. In 1964 the subspecies was first reported in Australia and since then has apparently proliferated across the north of the continent, but they are interbreeding with the indigenous brolga (*G. rubicundus*, Fig. 13).

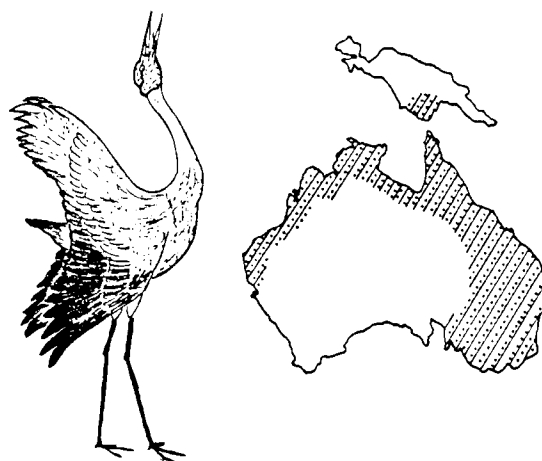


Fig. 13. Distribution of the brolga crane in Australia, New Guinea, and Papua.

Ignorance is perhaps the greatest barrier to crane conservation. Often little or nothing is known about the distribution or biological needs of a population, data that are fundamental to any conservation proposal. For example, little is known about the northern population of wattled cranes that inhabits western Ethiopia, and the birds could be lost before the saving hand of conservation is extended, as has occurred with the eastern sarus crane in the Philippines. In 1979 Peace Corp Volunteer Karen Madsen searched the remote northern valleys of Luzon, Philippines, and found that the remnant wetlands had been turned into rice paddies in the mid-1970's; the last crane had been seen in 1978. The Philippine Government is interested in a restocking program using captive birds produced at ICF, the National Zoo's Conservation Research Center, and Vogelpark Walsrode--stock derived from several birds imported from Australia in 1972.

The now-extinct Philippine sarus may have been genetically distinct from the Australian sarus, just as the rare Cuban sandhill crane is distinct from the Florida sandhill found nearby on the mainland. If the relict group of Philippine sarus had been discovered, studied, and conserved 5 years ago, the genotype perfected to adapt to that area would have survived and the tremendous risk and expense of a reintroduction program avoided. But ignorance claimed the Philippine sarus. Researchers got there too late.

This ignorance is not the fault of government officials, developers, or the local people but is the responsibility of ornithologists and conservationists.

We have found that after accurate scientific information is secured, and such material is presented in the proper manner to the local authorities, in most situations there is strong interest in implementing conservation measures. George Archibald recalls a 1978 meeting with a high official of the Ministry of Justice in Kabul, Afghanistan, regarding litigation to prevent the hunting of Siberian cranes that migrate through the country between breeding grounds in the USSR and wintering regions in India. The official expressed genuine concern for the cranes, particularly because he had shot 1 the previous year, believing that there were perhaps thousands migrating through mountain passes of neighboring Kashmir. He did not know that the specimen he shot constituted about 2% of the entire west-Asian group of Siberian cranes. When he realized the seriousness of the situation, he immediately initiated conservation action.

Table 1 and Figure 14 present, by zoogeographic regions, an alphabetical listing of countries containing cranes, the species found in each country, and whether they are residents, passage migrants, summer visitors, or winter visitors. Researchers in each country should determine what cranes are native to their country, compile all available information on the birds, determine gaps in man's understanding of the species, initiate appropriate research, then mold and present conservation proposals. International funding agencies (e.g., the International Council for Bird Preservation, the New York Zoological Society, and the World Wildlife Fund) are interested in supporting basic research that is conservation oriented.

Table 1. Distribution of cranes by country.

Species	Number of countries	Resident	Passage	Summer visitor	Winter visitor
Crowned (black)	22	15·0·5·0 ^a	0·2·0·0		
Crowned (gray)	18	15·0·0·2			
Demoiselle	42	0·0·0·1	25·3·0·4	6·0·2·0	13·9·0·7
Stanley	6	4·0·0·1	1·1·0·0		
Wattled	15	10·0·1·4			
Siberian	11		7·0·0·1	1·0·0·0	3·2·0·0
Sandhill	7	1·0·0·0	4·0·0·0	4·0·0·0	2·1·0·0
Sarus	13	5·0·0·8			
Brolga	3	3·0·0·0			
White-naped	7		6·0·0·0	3·0·0·0	4·1·0·0
Hooded	8		7·0·0·1	2·0·0·0	3·2·0·1
Common	64		47·1·1·5	11·0·11·0	27·4·0·7
Whooping	3	0·0·1·0	2·0·0·0	2·0·0·0	1·0·1·0
Black-necked	7	1·0·0·0	5·0·0·2	2·0·0·0	5·0·0·2
Red-crowned	7	1·0·0·0	2·1·0·0	2·1·0·0	3·2·0·0

^aNumber of countries in which the species is regularly present·other countries in which the species is irregularly present·additional countries in which the species formerly occurred·additional countries in which the species may occur.

Some may argue that crane conservation is fine for developed countries such as Japan, USA, USSR, and West Germany but not practical or of interest to the developing nations. As so eloquently elucidated by Prime Minister Indira Gandhi at the 1972 Conference on the Environment in Stockholm, this thesis is an illusion of the developed countries, an illusion quickly dispelled when we consider the satellite network of wildlife reserves in China, Cuba, India, Iran, Zambia, and many other countries.

We have repeatedly found that if an individual has the basic information, a genuine enthusiasm for conservation, and the willingness to communicate with appropriate channels, conservation proposals are heartily accepted and implemented. George Archibald recalls the situation along the Han River estuary in the Republic of Korea, a 40-km² spread of magnificent salt marshes that in 1973 was zoned for agricultural development by diking. Surveys in 1973 and 1974 by Dr. Kim Hon Kyu indicated that the area probably provided critical migration and winter habitat to most, if not all, whitenaped cranes that visit Japan and Korea each October through March. A proposal was sub-

mitted to the Ministry of Culture and Information, development plans were curtailed, and within 4 months the estuary was protected as a Natural Monument, although it was just 15 km from Seoul and was needed for agriculture in the tiny, developing, isolated, and overpopulated Republic of Korea. Conservation of rare cranes came first, a value priority to be emulated in other countries to ensure a quality environment for man and for wildlife.

PROJECTS OF THE 1980's

The next decade will undoubtedly include an exponential bloom of crane conservation programs. This analysis is based on the spiral of advance in the past 3 decades that began with Dr. Lawrence Walkinshaw's pioneering work on the sandhill crane (Walkinshaw 1949, 1973), Dr. Wolfgang Makatsch's studies of the common crane (Makatsch 1970), and Dr. Tadamichi Koga's efforts with the rare cranes of east Asia. The first international symposium on cranes was held at ICF in 1975, and 40 research reports were published (Lewis 1976). The second symposium, the 1978 Crane Workshop, convened at Aransas National Wildlife Refuge in 1978,

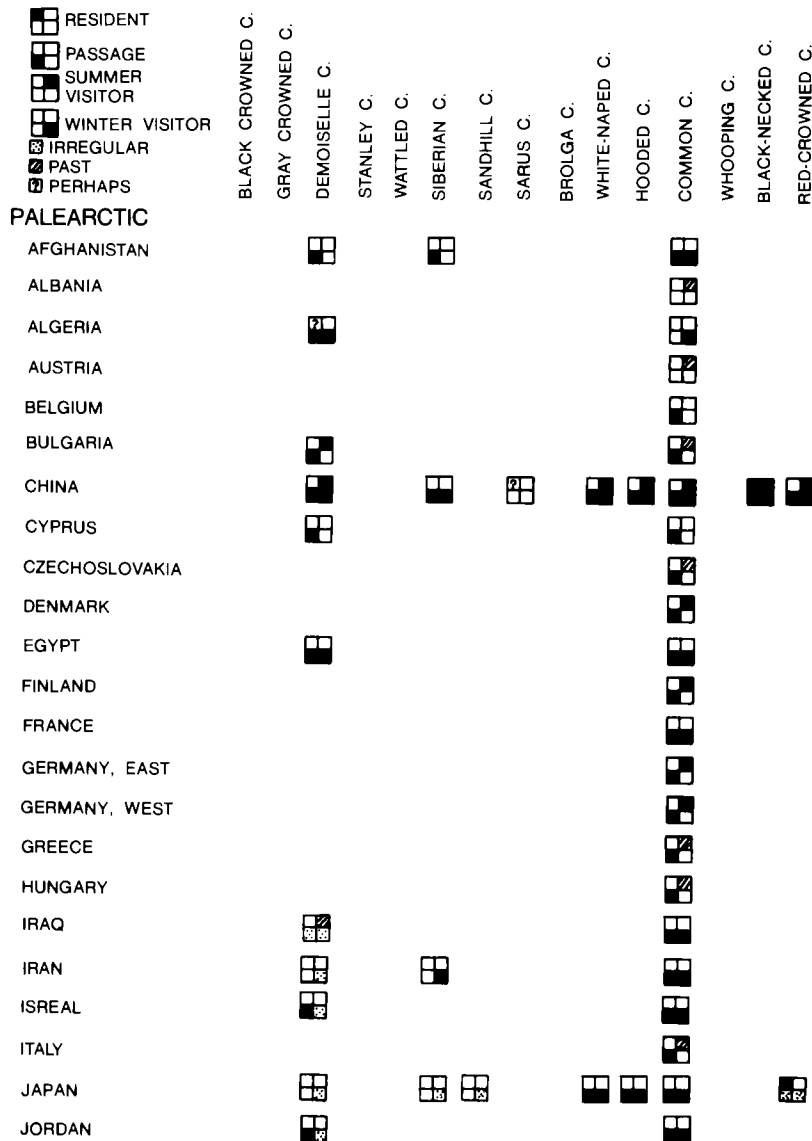


Fig. 14. Distribution of cranes by country.

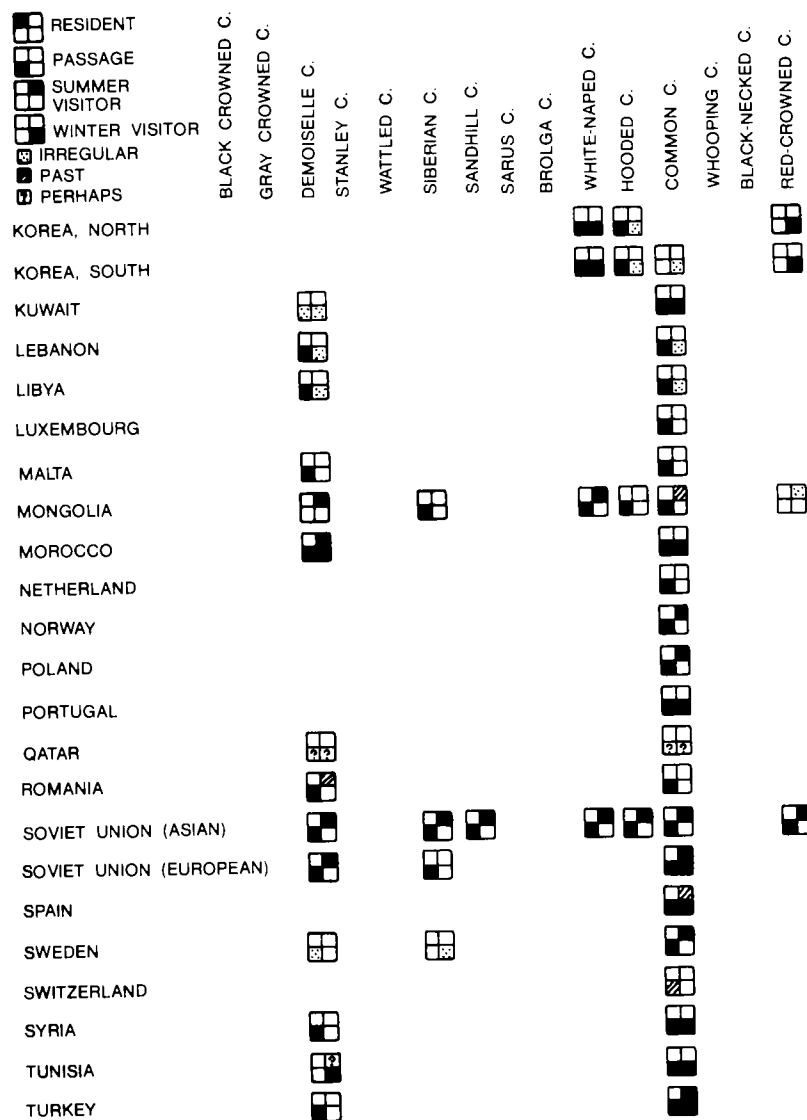


Fig. 14. Distribution of cranes by country (cont'd.).

and 36 papers were published in the proceedings (Lewis 1979).

Twenty-two reports were prepared through the 1970's by members of the International Council for Bird Preservation (ICBP) World Working Group on Cranes. Twenty-one papers presented at the February 1980 crane symposium in Sapporo, Japan, along with 26 invited papers, are presented in this volume. In February 1982 ICBP, ICF, and the World Wildlife Fund-India hope to convene another international symposium on cranes at the Keoladeo Ghana Bird Sanctuary near Bharatpur, India. The interest in cranes and crane conservation blossoms, allowing the authors of this paper to suggest possible research and conservation undertakings for the 1980's.

ESTABLISHING NEW POPULATIONS

The cross-foster experiment with whooping cranes and sandhill cranes is expected to continue in Idaho

until 15 breeding pairs of whooping cranes are established. After that is accomplished a similar program probably will be undertaken in southwest Ontario, Canada, using the Lake State's greater sandhills as foster parents to establish an eastern group of whoopers that winters in Florida. The final objective may be the reestablishing of a nonmigratory group of whooping cranes in Louisiana's southwest coastal marshland by allowing caged birds to gradually fly from their confines and establish themselves as sedentary or potentially sedentary cranes similar to the Mississippi sandhill in Mississippi, USA, the wattled crane in Swaziland, the eastern sarus in the Philippines and Thailand, and common cranes in England and France.

The Soviets and Iranians may continue to cooperate in establishing a new and secure population of Siberian cranes that winters in the Arjan National Park, Iran, and breeds near the Oka Reserve in the USSR. Since 1976 more than 200 common cranes have been

	RESIDENT	PASSAGE	SUMMER VISITOR	WINTER VISITOR	IRREGULAR PAST	PERHAPS	BLACK CROWNED C.	GRAY CROWNED C.	DEMOISELLE C.	STANLEY C.	WATTLED C.	SIBERIAN C.	SANDHILL C.	SARUS C.	BROLGA C.	WHITE-NECKED C.	HOODED C.	COMMON C.	WHOOPIG C.	BLACK-NECKED C.	RED-CROWNED C.		
UNITED KINGDOM																							
WESTERN SAHARA																							
YUGOSLAVIA																							
ETHIOPIAN																							
ANGOLA																							
BENIN																							
BOTSWANA																							
BURUNDI																							
CAMEROON																							
CENTRAL AFRICAN EMPIRE																							
CHAD																							
CONGO																							
DJIBOUTI																							
EQUATORIAL GUINEA																							
ETHIOPIA																							
GABON																							
GAMBIA																							
GHANA																							
GUINEA																							
GUINEA-BISSAU																							
IVORY COAST																							
KENYA																							
LESOTHO																							
MALAWI																							

marked with wing tags in the Arjan National Park and several have been seen on their breeding grounds west of the Urals in the USSR. Eggs can be transferred from captive Siberian cranes and substituted into the nests of the common cranes in a cross-foster experiment similar to the whooping crane-sandhill crane experiment in Idaho, USA.

If the wintering grounds of the eastern group of Siberian cranes is not located and protected in southern China, a cross-foster experiment might be considered, using the lesser sandhill crane (*G. canadensis canadensis*) as a foster species. Sandhill and Siberian cranes are sympatric in northeast Siberia. About 30,000 sandhills migrate over the Bering Strait to winter in the southwestern USA, but the approximately 300 Siberian cranes migrate southwest to the Yangtze Basin of China. The Siberian-sandhill cross-foster experiment would establish a migration pattern of Siberian cranes to the USA, a region not native to the species. Sandhills are hunted on their migration

route and wintering grounds. To most hunters the Siberian cranes would be indistinguishable from whooping cranes at a distance; although the species are distantly related and in separate genera, they are about the same size and white with black primaries. The project warrants serious biological and political consideration before eggs are transferred from Siberian crane nests to nearby sandhill crane nests.

SUSTAINING EXISTING POPULATIONS

As the wetlands shrink and agriculture increases, although the cranes are protected as individuals, there is a limit to which their space and habitat needs can be compressed. With the inevitable increase in wetland degradation, programs should be developed to help the cranes coexist with man. An excellent example concerns the red-crowned cranes in Hokkaido, where the cranes are revered as Special Natural Monuments but their wetlands are gradually being drained. Perhaps Japanese researchers and conservationists can

learn something from the Indians and their sarus crane.

Habitat imprinting may be important in cranes, as clearly occurs in many other groups of birds such as raptors. An Indian sarus chick reared along a slough amid agricultural fields, villages, and frequent contacts with man selects that type of habitat for nesting 2 years later and thus assures success of the species in cohabitation with man. Conversely, a red-crowned crane chick reared in the wilderness of Hokkaido, where its parents may defend a breeding territory including 5km² of wetland, may have no contact with man until autumn, when the cranes gather at feeding stations. These chicks may imprint on a wilderness habitat and, when sexually mature, search for such a region in which to breed. Unfortunately, as Japan's great wetlands are consumed by development, the cranes may soon find themselves in an India-like environment with small wetlands surrounded by agricultural fields and human communities. Will the red-crowned cranes be able to adapt to breeding in small wetlands near man?

At Kushiro Crane Park, Hokkaido, captive red crowned cranes have successfully reared young in wetland enclosures of less than 0.4 ha, indicating that wetland size is not critical to rearing chicks if adequate natural foods are available. Perhaps captive reared birds that are imprinted on a small wetland near humans should be released on similar areas in other parts of Japan to begin a more human-adapted crane population that might proliferate throughout densely populated Japan, just as the sarus have in India. Captive-produced cranes might also be released with relict wild populations to bolster their numbers.

After cranes have bred they abandon their nesting territories, flock, and in the instance of migratory cranes, fly long distances to their wintering grounds. About 150 of the red-crowned cranes that nest on mainland Asia winter along or near the Demilitarized Zone in Korea. Soviet and Chinese colleagues report man's destruction of the nesting habitats of these cranes. The impeded productivity of the flocks that winter in Korea is reflected in the number of young cranes, which are readily identified by their rusty brown

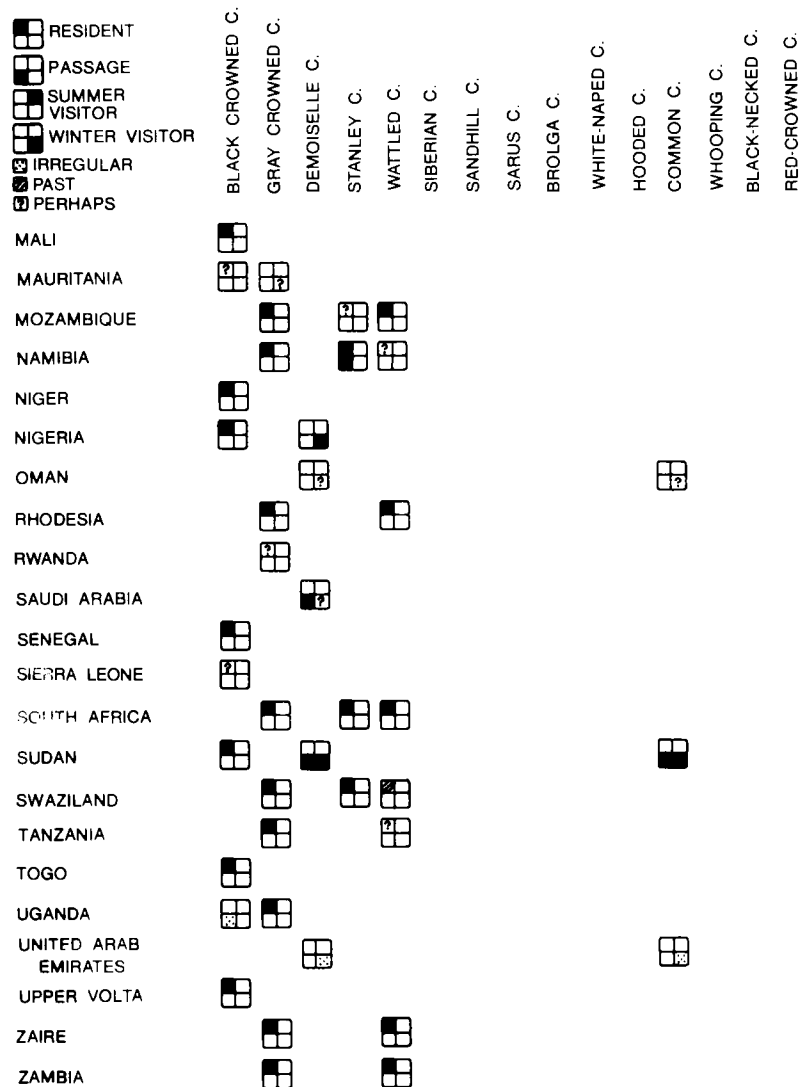


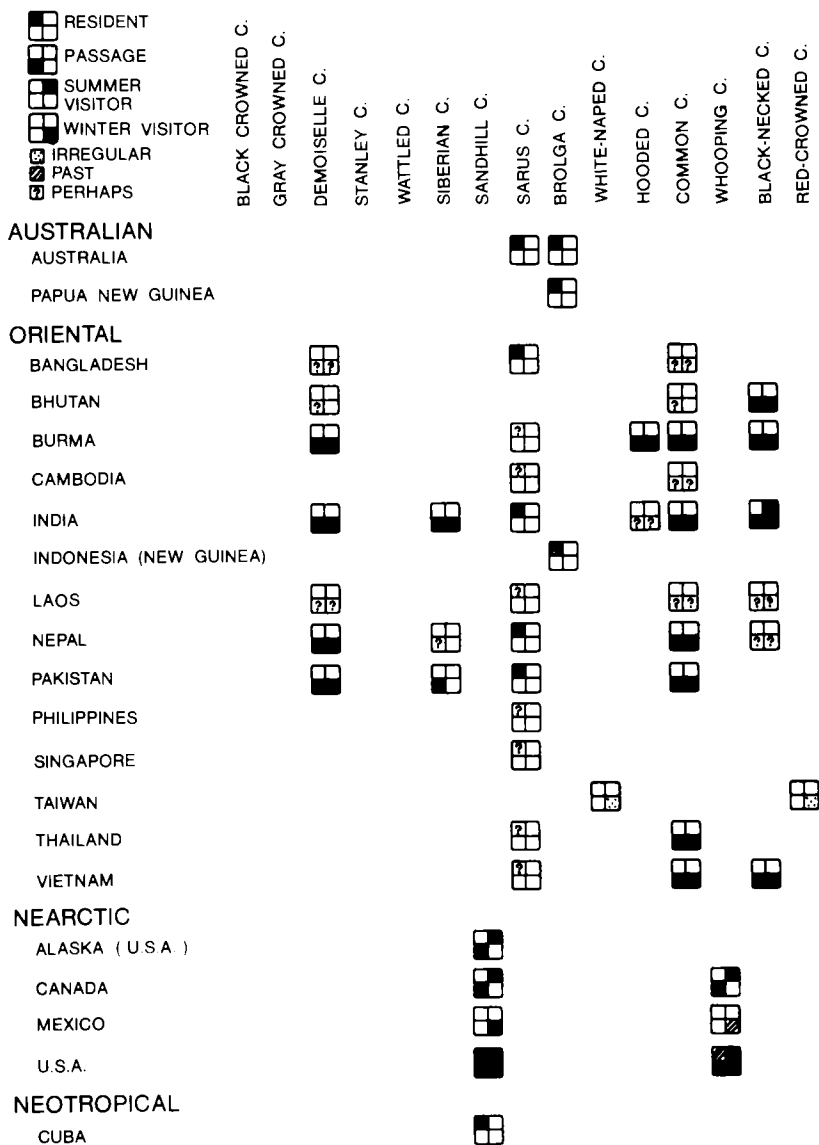
Fig. 14. Distribution of cranes by country (cont'd.).

plumage. A thriving crane population in winter should include 10 to 15% as birds-of-the-year; red-crowned flocks wintering in Korea contained only between 1 and 3% young during each of the past 3 winters.

To sustain and perhaps bolster the red-crowned cranes wintering in South Korea, experiments will be conducted using the white-naped crane that also winters along the DMZ to develop a technique whereby captive-produced cranes might be incorporated into the populations of wild migratory cranes. Male, wing-clipped, captive-produced cranes are to be placed in large enclosures beside the DMZ, separated by a visual barrier, and a short distance from captive female cranes. Cranes in both enclosures are expected to attract wild cranes, and wild and captive birds may pair. As pairs are established, the clipped primary flight feathers of the captive cranes will be reconstituted using a rachis plug and glue, thereby allowing the captive cranes to fly free with the wild cranes. If the experiment succeeds with the white-naped cranes, the same technique can then be applied to the critically endangered red-crowned cranes.

While efforts are underway in Korea to bolster the remnant flock of red-crowned cranes, researchers in Kyushu, Japan, will probably be managing the dilemma of the enormous congregations of hooded and whitenaped cranes at the Arasaki feeding station. The Arasaki problem indicates that the best intended conservation programs can become a great problem for man and for the birds unless the program incorporates basic biological consideration such as disease risk.

Breeding habitat and winter food are critical to crane survival, but so is a seldom discussed ingredient—proper, protected, and private roosting areas in the nonbreeding season. Hooded cranes wintering in a hilly area near Yashiro in western Honshu, Japan, illustrate the importance of the crane roost. The cranes are strictly protected, are given all the food they need at an artificial feeding station, and there is an abundance of natural foraging habitat in the harvested rice fields throughout the valleys. However, the hooded cranes roost on secluded, slightly flooded rice paddies high in the hills. To protect these roosts the government bought some land and a



small area is kept open for roosting by cutting the grass and weeds to provide the shallow water and open space that the birds require.

Many factors have led to the loss of additional ideal roosting habitat. Some farmers are abandoning rice farming, and their paddies have become overgrown with tall grasses, bushes, and trees. Other farmers are using a new drainage technique that allows planting a winter crop in the rice paddies but eliminates the flooded field that the cranes require. The birds have also been disturbed by livestock housed near the rice paddies and by new houses built in the hills. Unfortunately, another area of rice paddies was destroyed when a golf course was constructed.

Simultaneously the crane population decreased, although productivity, as indicated by the number of pairs with young, indicated that the population should be increasing. Clearly many cranes were abandoning the Yashiro Valley and joining the massive flock at the Araski feeding station south of Kyushu, where a large man-made roosting pond was available. Mr. Nobuki Kawamura, who has been studying the hooded cranes at Yashiro for several decades, firmly believes that alteration or disturbance at the roosting sites is the reason for the movement of cranes from Yashiro and thus the decrease in the population.

The importance of proper, protected, and private roosting areas is perhaps best evidenced in Korea, where the white-naped and red-crowned cranes roost in the no-man's-land of the DMZ but sometimes fly outside the DMZ during the day to feed in agricultural areas. If protected roosting areas could be established outside the DMZ and its buffer zones, we believe that both crane species would flourish in winter throughout much of the Republic of Korea because they adapt to feeding in agricultural areas in winter if not molested by hunters, trappers, and photographers. Undoubtedly, the same principle applies to wattled cranes in Africa that sometimes congregate in flocks in secluded areas during the wet season.

If eggs and birds are to be issued from the captive-propagation centers to the field, care must be taken to ascertain the health of such specimens to avoid introducing pathogens into the wild crane populations. The isolation of the deadly crane Herpes virus at ICF verifies that there are epidemic diseases in cranes that have the potential of rapidly destroying large numbers of birds. Captive cranes should have regular health checks, particularly before birds are moved from 1 center to another or from captivity into the wild.

EPILOGUE

The crane is a superb symbol of environmental quality both because of its esthetic appeal, the magnitude of its habitat requirements, and its need for respect from or isolation from man. Saving a crane population also means conserving an entire wetland ecosystem or chain of such environs that line migration routes, regions in which the crane stands at the peak of the ecological pyramid. The presence of these stately birds signifies quality environment, an environment that man is striving to attain for himself but can never attain without respect for nature. The crane can be the symbol of man's effort to live in harmony with nature, and the saving of cranes would be a testament to man's victory.

In an age when powers unleashed by warfare can destroy life on earth, mankind from politically polar-

ized nations must act to defuse the atmosphere of mistrust and cultivate a climate of cooperation. Cranes fly freely over political boundaries that often cannot be traversed by man without bloodshed. Information exchanged on these majestic birds, which are of interest to all nations, can be a means of reducing tensions among rival nations. Such exchange can assume greater substance if individual cranes are marked and thus recognized. Marking cranes does not hurt the birds but provides scientific data to improve man's understanding of crane biology and to improve the security of environment for both man and birds.

As a service to anyone interested in marking cranes, the International Crane Foundation will provide brightly colored, alpha-numerically engraved, 5-cm-tall plastic tibial leg bands that are readily attached to preledged or otherwise flightless cranes or to full-winged cranes that are trapped. Please indicate the species or subspecies you wish to mark, the number and colors of bands requested, and address your request to the International Crane Foundation, City View Road, Baraboo, Wisconsin 53913, USA.

We hope the 1980's will be a decade unparalleled in crane research and conservation and that our cooperative work will help provide that quality environment we all seek.

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THE CRANES MUST LIVE¹

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There are few people who are not familiar with these large and elegant birds, but not everyone has had the chance to see them close at hand in nature. Their trumpet-like calls announce the return of spring, and on frosty October mornings the sight of a wedge of cranes flying south reminds us that the ephemeral gold of autumn will soon be gone, too.

The crane we know best is the gray or common crane (*Grus grus*) which can be encountered, either nesting or perhaps just while molting or migrating, throughout the Soviet Union except for the Arctic regions, the far northeast, and the Kamchatka Peninsula. This crane lives also in many countries of Western Europe and in the northwest of Mongolia, and spends the winter in central Africa, near the Mediterranean Sea, and in southern Asia. The family *Gruidae* includes 14 other species, however, inhabiting all continents except Antarctica and South America, and half of all species live on Soviet territory. These resident species are the common, hooded (*G. monacha*), white-naped (*G. vipio*), red-crowned (*G. japonensis*), Siberian white (*G. leucogeranus*), sandhill (*G. canadensis*), and demoiselle (*Anthropoides virgo*).

Because of their long legs and necks, cranes are often confused with storks and herons, but they are not closely related and differ much in appearance, habits, and life history. Cranes are ground birds, and are never seen perched on trees, bushes, roofs, or towers, nor do they nest on such things. Only the African crowned crane (genus *Balearica*) likes to roost in low trees, and sometimes builds its nest there. They walk with unhurried steps and do not make sharp turns, unexpected short dashes, or abrupt stops; they usually hold their necks in a slight curve, and their bodies horizontal. Their footprints show only 3 toes because the hind toe, which is situated higher than the others, touches the ground only with the nail. They are excellent runners and if frightened can go as fast as 40 km/hr.

Cranes are at home in marshland, fond of bathing, of wading in shallows, and of resting while standing in open water; they swim well. They take to the air with ease, after a short run. They fly slowly, flapping their wings rhythmically. In continuous flight the head, neck, and legs are extended in 1 line, though in cold weather the feet are sometimes hidden in the plumage until the bird is ready to land. Flocks in flight take the shape of a wedge, an obtuse angle, or of echelons.

Cranes are not brightly colored; their feathers are usually white, black, brown, and all possible shades of gray. The gray color predominates in the plumage of the common crane; only the sides of the head and the upper part of the neck are white, while the top of the head, the throat, the lower part of the neck, and all of the large wing feathers (remiges) are black. Sexual dimorphism is not expressed in coloration but in size, the males being somewhat larger. Most cranes

in adult plumage have brightly colored unfeathered skin on the head; in the common crane this takes the form of a red patch on the crown.

Among cranes that live in regions where the marsh water contains much dissolved iron, the plumage gradually acquires a brownish stain. This discoloration results from the habit of rubbing the feathers of the back and wings with the beak, which is often sullied with rusty water and mud. The iron stain is further worked into the feathers while the bird carefully preens each one. In autumn, after the annual molt, the contour feathers are once again their natural color. Flight feathers are renewed once every 2 years; they all fall out simultaneously and render the bird temporarily flightless. Exceptions to this rule are the demoiselle and the crowned cranes².

When a crane's wings are folded the secondary feathers, elongated, curved, and usually fluffed apart, form a peculiar embellishment covering the short tail. They are an effective part of display when an alamed or excited bird raises them. The "fringe" on the wings of South Africa's Stanley crane (*Anthropoides paradiseia*) is so long that it trails on the ground, and when the bird is flying it looks like an extra pair of wings, hence the (alternative) scientific name "four-winged" (*Tetrapteryx paradisius*).

The sonorous trumpet-like calls of cranes, audible several kilometers away, are unmistakable. The loops of the trachea lying within the breastbone function as a resonator and give the voice its carrying power. The windpipe of the crowned crane is differently built, and produces only a plaintive cry. Cranes give voice in groups or alone, while taking flight and while flying at various heights, while settling down to feed or for the night, at any time of the year or the day, but most intensively at dawn. For example, in spring while the sky is still dark a single bird will start to call; a 2nd bird answers, and then 1 by 1 all the others within range take it up until, by the time the sunrises, the chorus reaches its triumphant climax. Calls like these, given with varying intonations and frequentness, and as rolling trills and guttural sounds like the cackling of geese, serve not only as communication between partners and with other members of the flock, but are also used to express agitation, to warn about danger, and to accompany the mating ritual widely known as dancing.

One, 2, or a group of birds walk quickly in a circle during a dance, pause and open their wings, bow low, almost touching the ground with their beaks, snatch up, fling, and try to catch twigs, pebbles, clods of dirt, rootlets, or feathers. With surprising lightness and grace they leap a meter into the air, balancing there momentarily on their wings. Having landed, they elegantly advance 1st 1 foot, then the other, and then suddenly stand still, with neck outstretched and head thrown back so that the beak points up.

Dancing is not influenced by sex, age, or number of participants, and is done in any place and at any hour

¹Originally published in *Okhota i Okhotnich'e Khoziaistvo* (Hunting and Game Management) 6:20-21. Reprinted with special permission of Copyright Agency of the USSR.

²Editor's note: The sandhill crane is now known to also be an exception to the rule.

and season (although little dancing is performed while molting). There have been situations when dancing was provoked by a person approaching a nest which had eggs in it, by a dog or eagle who appeared among a group of cranes, and by a hapless frog who became the object the sportive cranes threw about. Tame birds, even young ones, will dance, imitating some of the movements of their wild brethren.

Only at the end of winter and in early spring does dancing coincide with increased sexual activity and nuptial play; at this time immature birds form pairs (it is believed that they mate for life) and mature birds prepare to breed and nest. The biological meaning of dancing is still not clear, but it is obvious that it is not simply part of the males' nuptial behavior. It is most probable that dancing is an external expression of any kind of excitement or emotion, and in certain situations could just be play.

Cranes are inhabitants of open expanses, but such places are everywhere being eliminated by man in the name of economic development, which has unavoidably led to decreases in the populations of these birds and to sporadic distribution in their former ranges. They prefer marshes and damp meadows either on plains, wide river floodplains, and along lake shores, or on plateaus, even highly elevated ones (the black-necked crane, *Grus nigricollis*, lives in the mountains of Tibet at 3,400-5,000 m above sea level). In the forest zone of the USSR the common crane lives in wide moss fens or hillock bogs, or, if such are not available, in boggy open woodland or in little (about 1 ha) swamps surrounded by trees. Some species are found also on dry steppe and semidesert.

Although cranes are social birds, they do not form nesting colonies. In spring, mated pairs, whose members are touchingly devoted to each other, leave the flock and settle on separate plots of ground where, if undisturbed, they will nest year after year. The male and female both build the nest, usually choosing as inaccessible a place as possible. The nest is a fairly primitive structure of bunches of sedge and cereal plants, rootlets, moss, dry reeds, and twigs, either uprooted or gathered from nearby, and piled on trampled grass or on a hummock. The demoiselle and Stanley cranes, however, lay their eggs in small depressions in the ground from which the grassy lining has been removed. The black-necked crane does so also at times, and in some circumstances will build a little mucky island for its nest, after the fashion of flamingos. A crane's clutch contains 2 eggs, rarely 1 or 3. The eggs are either olive-brown, pale yellowgreen, or cream, with spots; only those of the crowned crane are solid blue-gray, without markings.

Cranes are extremely wary. They will circle continuously, 1st coming low, then regaining altitude, until they are convinced that the place where they want to land is safe. A flock that is feeding or resting always has "sentries" who survey the horizon from their full height (which in some species can be 160 cm) and give warning at the slightest danger. They are most watchful when in the vicinity of their nests. They wade or swim up to the nests only from a distance and just as unnoticeably leave, taking wing and calling only when a safe distance away. They be-

gin incubation when the 1st egg is laid and continue for 28 to 35 days. The female common crane sits most of the daylight hours; the male stays nearby and is the first to note any danger, about which he informs his mate. He replaces her on the nest at night and whenever she goes off for a short time to feed.

A newly-hatched chick comes into the world covered with thick cinnamon-ocher down, and can run and swim before it has hardly had time to dry off. On the next day it is ready to set out to forage with 1 of the parents. Its voice is a rather loud squeaky whistle. When the last chick to be hatched has gained a little strength, the brood leaves the nest.

Young birds fledge at 10 weeks of age. Their parents, with whom they have stayed constantly, have in the meantime molted completely and have just regained their own ability to fly.

In the 2nd to 5th year of life, depending on the species, cranes become sexually mature. Those individuals of any age who are not actively reproducing become nomadic and wander, usually in small groups, away from nesting cranes. Common cranes frequently will gather by the thousands at a productive feeding ground. In such places year-old birds retire into impassable reedbeds and swamps in May and June and shed all their flight feathers. A little later in the summer the other young birds and unmated adults molt either partially or completely.

In autumn, families rejoin the flocks of feeders; they all feed and rest together and then fly off to wintering grounds. In such flocks the birds hatched in the current calendar year can always be distinguished by their voices, which have not yet changed much from a chick's squeak, and by their plumage, which, on the feathered head (another clue), the neck, back, and part of the remiges, is still pale cinnamon-ocher.

Although cranes eat a variety of foods they are predominantly vegetarian. They eat both the green parts of wild and cultivated plants and also the stalks, roots, fruit, and seeds. Their diet often includes insects, worms, frogs, and, less frequently, snakes, small rodents, and the young of other birds. The sarus crane (*Grus antigone*) that lives in northern India and in Indochina feeds mostly on fish and invertebrates.

Only the common and sandhill cranes are now fairly widely distributed, the former in Eurasia, and the latter in North America. The remaining species have very limited ranges, and their populations are declining. They are in serious danger. The Siberian white, whooping (*Grus americana*), hooded, red-crowned, and black-necked cranes are already listed by the International Council on Bird Preservation as rare and endangered species in particular need of special protection. The white-naped crane should be included also.

No crane species is yet among the birds that have become extinct since 1600. It is still within our power to keep their names off that Black List. The cranes must live!

TECHNIQUES FOR BREEDING CRANES IN CAPTIVITY

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Abstract: The International Crane Foundation (ICF) has worked for a number of years in an effort to develop and improve techniques for breeding cranes in captivity. Some of the procedures which have proven successful for propagating cranes are artificial insemination, good nutrition, and artificial incubation. Current research in the cryogenic preservation of crane semen will make the practice of artificial insemination even more prevalent in the future at various crane breeding centers. The ability to rotate breeders through semen transfer, and the feasibility of international shipment of frozen semen, will have a great impact on reducing inbreeding and increasing fertility in captive flocks. Other considerations in the management of cranes in captivity include their health problems and minimum requirements for housing. For some species special attention must be given to environmental stimuli which may be helpful in improving breeding results.

The ICF is a nonprofit organization dedicated to the study and preservation of the world's cranes. The foundation operates a captive propagation program with 14 of the 15 species of cranes at its headquarters in Baraboo, Wisconsin, USA. The goals of this program include the establishment of a "species bank" of each of the endangered species of cranes and the development of captive propagation techniques. It is hoped that offspring from these captive populations can some day be used in restocking efforts when conditions permit in their natural habitat.

HOUSING

The facilities for housing cranes at ICF vary somewhat according to the species and age of the bird. Because a majority of the cranes are cold hardy, each pair is given access to an unheated shelter of approximately 10 m² with dry wood shavings on a concrete floor. Species such as brolgas (Grus rubicunda), sarus cranes (G. antigone), and the African crowned cranes (Balearica pavonina) should be given heat in cold climates. The most frequent injury resulting from exposure to cold temperature is the loss of toes or toenails due to frostbite damage. Young birds can generally be kept in small flocks of mixed species for their first 2 years. These mixed flocks should be carefully formed to avoid overcrowding and to eliminate very aggressive dominant individuals.

Outside pens are generally about 110 m² surrounded by chain link fencing 2.4 m high and covered with 50-cm mesh nylon flight netting. Adjoining fences are covered with canvas or Christmas trees to act as visual barriers between pairs. These visual barriers allow each pair a certain amount of security in their newly established territory.

In some instances additional equipment is placed in the pen to provide environmental stimulus. This equipment may include floodlights on time clocks to extend photoperiods or water sprinklers to simulate rainfall. Successful breedings at several institutions have resulted from the use of extended photoperiods on Siberian cranes (G. leucogeranus), hooded cranes (G. monacha), greater sandhill cranes (G. canadensis tabida), and whooping cranes (G. americana). The first reproduction of brolga at ICF occurred during a study of the effects of artificial rainfall on brolga breeding behavior.

In many instances it is desirable to house birds as individuals rather than in pairs. This may be due to the incompatibility of some pairs, a surplus of 1 sex, individuals too old or too young to breed, birds imprinted on people, or the desire to prevent copulation in order to perform artificial insemination. Even though some birds may be kept physically separated it

is still important to give them visual access to a member of the opposite sex. Pair bonding will frequently occur through the fence and both birds may be brought into reproductive condition from this stimulus. Occasionally extra females can also be stimulated to lay eggs by housing them next to a sexually bonded pair. In these instances caution must be used to prevent injuries if the pair becomes aggressive towards the neighboring bird.

The aviculturist should also be aware of the potential for redirected aggression in these situations. If the male of the pair becomes extremely aggressive towards the he may attack his mate in frustration.

HEALTH MANAGEMENT

The most serious animal health problem to occur at ICF has been the outbreak of a previously unknown Herpes virus. This disease, since named Inclusion Body Disease of Cranes (IBDC), in 1978 infected a flock of 50 young cranes of several species and caused 40% mortality. To date there has been no recurrence of the disease and all birds that were exposed or suspected of exposure have been kept in isolation.

In September of 1979 ICF began a 2-year research project of IBDC in cooperation with the Veterinary Science Department of the University of Wisconsin at Madison. This project will attempt to develop reliable testing procedures to determine if a bird has had recent exposure to IBDC and if it is shedding the virus.

The primary course of action in controlling this and other diseases is good sanitation and management. Extensive sanitation measures have been implemented at ICF since the 1978 outbreak of IBDC. These measures include but are not limited to the use of disinfectant footbaths at the entrance to each pen, coveralls to be worn when handling birds, disposing of feces and bedding in plastic trash bags, separate scrub brushes for each water bucket, and strict cleanliness in the incubator room and chick rearing areas.

Other health problems most prevalent in our captive birds include salmonella, aspergillosis, gapeworm, and various injuries. Most minor injuries involve the bird's beak, toes, or wings and generally result from flying or running into fences. Other than the Herpes virus deaths, the next most frequent causes of mortality are cold stress, intraspecies aggression, and age related illnesses.

The health and well-being of all captive birds should be constantly safeguarded through a continuing program of preventive medicine. This program could include an annual health check of all birds, frequent

examinations for endo-and ecto-parasites, quarantine of incoming birds, isolation of sick birds, proper nutrition, and other good management practices such as pen rotation and avoiding overcrowded conditions.

DIETS

A feeding program was established that is economical, easy to handle, and provides for the nutritional needs of the birds because of the large number of cranes in the ICF collection and the emphasis on reproduction. This feeding program is based on 4 diets, each developed specifically for a certain time in the bird's life and for the changing seasons of a temperate climate (Table 1).

The Breeder Diet is fed to all adult birds 3 years old and older during the breeding season. It is started about 1 month before egg laying and continues until after the postnuptial moult. The only supplement given during this time is ground oyster shell offered free choice to all breeding age females. Consumption of the ground oyster shell varies greatly between individual birds. Studies at ICF indicate that many birds increase their oyster shell consumption near the end of the laying season. In some individuals the daily oyster shell consumption peaks approximately 48 hours before egg laying.

At the end of the breeding season the birds are placed on the Maintenance Diet for fall and winter; like the Breeder Diet, it is custom made in a 3/16inch (4.68-mm) pellet. During cold weather the birds are also given a small amount of whole corn daily for additional carbohydrates. The Maintenance Diet is fed year-round to immature birds for their first 3 years.

Newly hatched chicks are started on a 23% protein ration in a 1/8-inch (3.12-cm) pellet. The pellet size is not difficult for the birds to eat and seems to aid in teaching them to accept food during their 1st few days. At about 10-14 days of age the chicks are switched from the Starter Diet to the Grower Diet. The Grower ration is made in a small pellet similar to the Starter Diet but cut slightly longer. These diets are supplemented with vitamins and electrolytes in the chicks' drinking water during their first 4 to 6 weeks.

Feed is stored in paper bags (50 lbs.) in a cool dry room for not more than 6 to 8 weeks. Longer periods of storage may cause loss of vitamin potency and pellet integrity. All birds are fed each morning in small, single-serving plastic buckets hung on the wall inside the shelter. These buckets have an advantage over large wood hopper feeders, which attract rodents and absorb moisture. An important but often overlooked aspect of good nutrition is clean fresh feed daily in easy-to-clean containers. A controlled feeding system also provides the aviculturist an opportunity to observe fluctuations in daily feed intake.

Table 1. ICF crane diets calculated analysis.

Component	Starter	Grower	Breeder	Maintenance
% Protein	23	19.4	20.5	19.4
ME/kg diet	2,554	2,530	2,533	2,530
% Calcium	1.15	1.00	2.45	1.00
% Phosphorus	0.93	0.86	0.89	0.86

Daily feed consumption varies according to the time of year, the type of feed, and the individual's physiological condition. From feed studies conducted at ICF by T. A. Halibey (1979, Feed and feeding habitats of captive cranes, unpubl. rept., ICF) several generalizations can be made. The daily feed intake for 6 species of cranes averaged 4.7% of their body weight when fed a diet of 2,533 ME/kg. Females laying eggs consume much more feed than males and nonlaying females. Feed consumption for layers peaks approximately 24 hours before oviposition and declines significantly on days that eggs are laid. Surprisingly the peak feeding time is midday with early morning as the second highest in feed consumption.

ARTIFICIAL INSEMINATION

Some breeding centers, notably Patuxent Wildlife Research Center and International Crane Foundation, have implemented artificial insemination (AI) as a propagation technique in an effort to increase the fertility of crane eggs. Many of the problems which produce infertile eggs can be overcome using AI. Artificial insemination is practiced at ICF for a variety of reasons: prominent among these are when (1) individuals of a pair are incompatible because of behavioral problems and must be kept separated; (2) there is a shortage of unreleated, sexually mature males; (3) breeding age males are unable to copulate due to pinioning or other anatomical disabilities; (4) a bird is sexually imprinted on humans and will not pair with a crane; (5) a pair is physically capable of breeding but does not copulate due to 1 or more of a variety of inhibiting factors; or (6) new bloodlines are desired to improve the genetic variability in the captive flock.

The techniques of AI through the massage method have been described in other publications (Gee 1969, Archibald 1974, Gee and Temple 1978) and therefore will not be repeated here. Artificial insemination is as much an art as a science but it is not difficult to learn. The methods used vary somewhat between individual aviculturists and individual birds.

Generally it is accepted that the higher the frequency of insemination the higher the fertility rate. However, it is also true that the timing of each insemination is extremely important. Inseminations done 3 times a week and on days an egg is laid, a few hours after laying, should give satisfactory fertility. Results at ICF and Patuxent indicate that these postoviposition inseminations may be the most important in producing good fertility.

The use of AI on cranes will not only increase fertility in many situations but will also help to maintain genetic variability when captive populations are small. The only practical method of rotating males is through AI because cranes form fairly permanent pair bonds. With the development of crane semen freezing technology (Gee and Sexton 1979) the future of many captive breeding centers will include a properly managed AI program.

ARTIFICIAL INCUBATION

All eggs laid at ICF are removed immediately and transported to the incubator room. Eggs are always collected and handled with plastic gloves

to avoid contamination. In the incubator room the eggs are allowed to cool to room temperature and if extremely dirty they are gently washed with a damp sponge. When the egg reaches room temperature it is dipped in a commercial disinfectant such as a 20% quaternary ammonium solution diluted according to directions or a 1% betadine solution. After the egg has been dipped in the disinfectant it is allowed to dry and then weighed and measured. The egg number is written in pencil on the small end of the egg and it is placed in a forced-air incubator at 37.5°C dry bulb and 30.0° wet bulb. The eggs are automatically turned every hour in the incubator.

The humidity in the incubator will vary somewhat to meet the requirements of the various species of cranes. Recent observations on the poor hatchability of white-naped cranes (*Grus vipio*) indicate that the incubation humidity should be slightly lower, perhaps 27.2°C wet bulb. Correct incubation humidities can be determined to some extent by monitoring weight loss during incubation. Ideally the egg should lose between 12% and 16% of its original weight (Fig. 1). This is fairly consistent with the data collected on 65 species of birds (Rahn et al. 1979) which showed a 15% weight loss of eggs during natural incubation. It seems logical then to regulate humidity until the 15% weight loss is reached by a majority of the eggs set.

Unfortunately, the optimum incubation temperature and humidity requirements for all species of cranes have not been determined. Much more research and experience is needed in the artificial incubation of crane eggs in order to reach maximum hatchability of strong healthy chicks.

During incubation the eggs are removed from the incubator every other day for weighing. The eggs are allowed to cool to room temperature during these weighings. The eggs are candled 3 times during incubation; at day 10 to check fertility, day 20 to confirm viability of the embryo, and 2 days before hatching to determine the position of the chick in the shell before placing the egg in the hatcher.

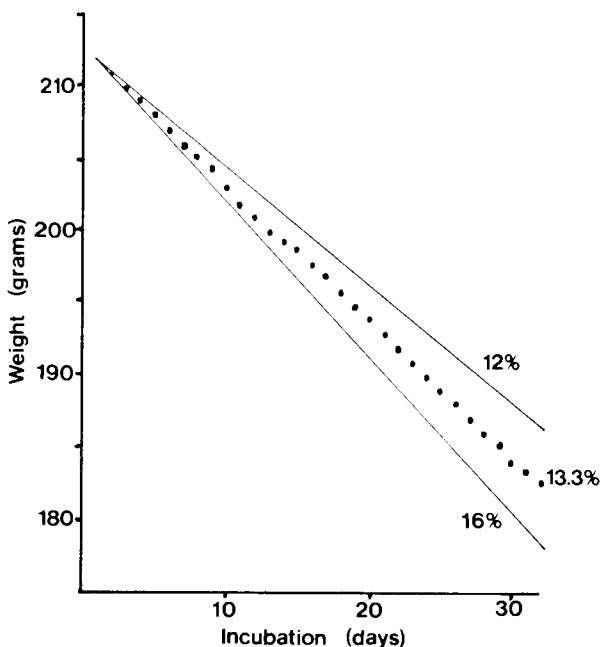


Fig. 1. Weight loss during incubation of red-crowned crane (*G. japonensis*) egg.

The hatcher is a large forced-air incubator set at 36.9°C dry bulb and 33.3°C wet bulb. The eggs are not turned while in the hatcher but weighing is continued every other day until pipping. The incubation period for most species of cranes will vary between 31 and 34 days. During the hatching process, which may take up to 36 hours, the egg is frequently sprayed with a warm water mist to keep the membrane moist. If the chick appears to be weakening and fails to hatch in 36 hours, help is given by carefully removing part of the shell over the air cell.

After hatching the chick is allowed to dry in the hatcher for 24 hours. During this time a feather duster is placed in the hatcher for security and warmth. The feather duster is moved with the chick when the chick is moved to the brooder room. Chicks reared with feather dusters appear to spend less time stress calling and are probably less likely to imprint on people.

CHICK REARING

When the newly hatched chick is removed from the hatcher it is placed in a brooder box located in a heated room. These boxes are approximately 1 m³ with an adjustable floor that permits varying heights in the box for chicks of different ages. The front of the box is a clear plastic door and the top is partly covered with clear plastic to allow light in the box. One side of each box has a removable screen panel. The screened side is situated to face the screened side of the adjoining box and allows visual contact between 2 chicks. The fine mesh screen prevents injuries caused by interchick aggression. The panels can be removed to introduce 2 chicks under supervision for short periods or to give 1 chick a larger area for indoor exercise. Each box is thermostatically heated and contains a backup heat lamp on a separate thermostat. The wooden floors are covered with indoor-outdoor carpeting which is changed twice a day.

The young birds are fed Starter Diet from a spoon for their first few days until they have learned to

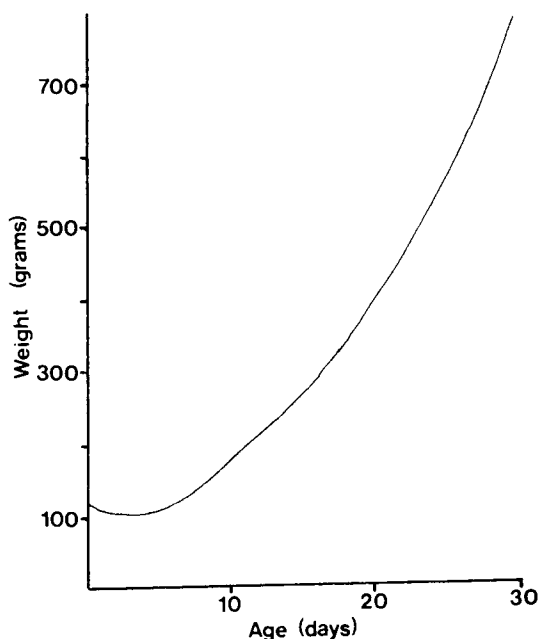


Fig. 2. Approximate growth curve for hand-reared crane chicks.

eat without assistance. Normally a chick will lose weight for the first 3 or 4 days before beginning to gain weight (Fig. 2). The chicks' growth rate must be watched closely to prevent overweight and later leg problems such as slipped tendons on the hock joint. At about 10-14 days of age the chicks' daily weight gain will approach 20%; when this occurs the chicks are switched to the Grower Diet. The lower protein of the Grower Diet helps to slow down the growth rate and gives the birds' legs time to strengthen.

Exercise is extremely important to development of healthy crane chicks. Weather permitting, the chicks are taken outside for exercise from day 1 through fledging. A shallow pool provides swimming exercise for the very young and older birds will bathe often if given access to water. During exercise periods the birds frequently eat many grasshoppers, crickets, and other insects. Chicks are normally exercised in small groups to allow the young birds to follow older birds and thus minimize improper imprinting. It is important that these groups be supervised closely to prevent fighting between chicks. Younger birds are more aggressive but eventually outgrow these tendencies.

When a crane chick reaches 2 weeks of age it can be moved to a larger pen and given access to an outside run. The larger pen's floor should be covered with sand for ease of cleaning and to provide a suitable substrate for the bird's feed.

Very young birds may develop crooked toes that can be easily corrected by applying tape around the bent toe. The tape should be removed after 12 hours and retaped for another 12 hours if the condition persists. Exercise on a soft surface helps to reduce the frequency of crooked toes. Grass-covered runs outside and sand-covered floors inside work well for preventing foot problems.

SUMMARY

Captive propagation of cranes plays an important role in the preservation of these rare birds. The

basic avicultural techniques for breeding most species of cranes are known and need only be applied for successful propagation. As in any intensive breeding program, good management is necessary to avoid such detrimental consequences as inbreeding, diseases, overcrowding, and surplus animal problems. With the cooperative efforts of many institutions and governments, these problems should be minimal.

The development of techniques for the cryogenic preservation of semen and subsequent international shipment of frozen semen should help greatly in increasing the genetic variability of small captive populations. As captive propagation efforts continue to succeed the implementation of restocking programs can become a reality if hopes are realized.

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CHROMOSOMES IN GRUIFORMES, WITH NOTES ON THE CHROMOSOMAL DIAGNOSIS OF AVIAN SEX

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This paper deals with the following aspects of avian chromosomes: (1) The number and morphology of bird chromosomes; (2) The principle and techniques for the diagnosis of sex on the basis of the sex chromosome constitution, and (3) Karyotypes of cranes and some related species belonging to Gruiformes.

CHROMOSOME NUMBER, MORPHOLOGY, AND SEX CHROMOSOMES IN BIRDS

The diploid chromosome numbers of birds range from 52 to 98 with a mode at 80 among the 227 species reported examined to date by means of the modern cytogenetic techniques (Table 1). Some of these numbers are approximate due to the difficulty in counting the exact number of minute chromosomes (microchromosomes), but others are exact, especially for the species having smaller numbers of microchromosomes. The lowest number (52) is from the genus *Falco* (*F. tinnunculus* and *F. biarmicus*) (de Boar 1976) and the highest from the snipe (*Gallinago gallinago*) (Hammar 1970). Cranes have 80± chromosomes.

A typical bird karyotype consists of several pairs of large to medium-sized chromosomes (macrochromosomes) and a number of microchromosomes, although the boundary between the 2 is not necessarily sharp (Fig. 1). Unlike mammals, females are heterogametic in birds, i.e., ZZ in the male and ZW in the female. Usually the Z chromosome is a medium-sized element comparable in size to the 4th to 5th autosomal pairs, whereas the W is 1 of the microchromosomes (Fig. 2).

On this basis we can predict the genetic sex of birds, even if their external sexual characteristics are not distinctive, e.g., eagles, storks, cranes, and immature individuals of diverse species. The chromosomal sexing is highly reliable and feasible to almost all species of birds studied to date. There are, however, some exceptions wherein the morphological differentiation of sex-chromosomes is uncertain, probably because they are in a primitive stage of evolution. Examples in the subclass Ratitae are, e.g., ostrich (*Struthio camelus*), Australian cassowary (*Casuarus casuarus*), and emu (*Dromaius novaehollandiae*), although the lesser rhea (*Pterocnemia pennata*) has morphologically differentiated sex elements (Benirschke et al. 1976), and the possible existence of a slightly heteromorphic medium-sized pair (no. 6) is suggested in a female greater rhea (*Rhea americana*) (Takagi et al. 1972).

CYTOGENETIC TECHNIQUES

Two simple methods are described here for avian chromosome preparations: a blood culture method (Takagi et al. 1972) and a feather pulp culture (Sasaki et al. 1968) method, both being without any harmful effect on the birds.

Blood Culture Method

The blood culture method is suitable for relatively large birds, e.g., cranes, eagles. The procedures are as follows:

1. Withdraw 1-2 ml of venial blood into a heparinized (5-10 IU) sterile syringe. Blood is usually

taken from the wing vein after thorough swabbing of the skin with 70% ethanol.

2. Place 0.3-0.5 ml of the blood into culture flasks with 3-5 ml of Eagle's Minimum Essential Medium (MEM) supplemented with 20% fetal calf serum and 0.05 ml of PHA (Phytohaemagglutinin-M, Difco, or Wellcome), and mix well.
3. After 3-4 days of incubation at 37-39°C, 0.1 µg/ml Colcemid is added to each flask. The flasks are gently swirled, and incubated for an additional 2-4 hours.
4. To harvest, remove the contents of the flasks after resuspension, and place into 15-ml conical centrifuge tubes.
5. Centrifuge at 1,200 rpm for 5 minutes, remove the

Table 1. Frequency distribution of diploid numbers for 227 avian species.

Diploid chromosome numbers	Number of species	
52	2	
54	1	
56	0	
58	1	
60	1	
62	5	
64	0	
66	19	} Lariformes Falconiformes Ciconiiformes Pelecaniformes
68	18	
70	5	
72	9	
74	7	
76	22	} Anseriformes Columbiformes Galliformes Gruiformes Passeriformes Strigiformes
78	27	
80	64	
82	29	
84	6	
86	4	
88	1	
90	2	
92	2	
94	1	
96	0	
98	1	
52-98 (Range)	227 (Total)	



Fig. 1. A metaphase spread obtained from a male greater flamingo (*Phoenicopterus ruber*).

supernatant, and add 1.5-2.0 ml 0.075M KCl solution to each tube.

6. Gently resuspend the cells and let the tubes stand for 10 minutes at 37°C.
7. Add 10 ml of freshly prepared methanol-acetic acid (3:1) and mix well.
8. Centrifuge at 1,200 rpm for 5 min, discard the supernatant, add 10 ml of the fixative, and resuspend the sediment.
9. Repeat step 8, twice or more, and resuspend the cells in 2-4 ml of fixative.
10. Place a drop of the final cell suspension on a clean slide, dry in air, and stain with Giemsa solution (3% in 1/15M phosphate buffer, pH 6.8) for 10 minutes. Rinse the slides in deionized water, dry well, and examine under microscope.

Feather Pulp Method

The feather pulp culture method is feasible for any species, especially for smaller ones. The procedures are as follows:

1. Remove a couple of growing feathers from the tail or wing.
2. After swabbing with 70% ethanol, cut off the base of the feather and place it in a sterile test

tube containing 3-5 ml of any kind of culture medium (Eagle's MEM will work) with 10% fetal calf serum.

3. The feather bases thus collected are slit with fine scissors in the culture room, and their contents are scraped off with tweezers and placed in a Petri dish.
4. Wash the pulp tissues with 3 changes of culture medium, if necessary with appropriate antibiotics, and cut the tissues into shreds with fine scissors.
5. Place the tissue fragments directly on the bottom of plastic culture flasks, feed Eagle's MEM supplemented with 15% fetal calf serum, and incubate at 37-39°C. Change the culture medium at appropriate intervals until a sufficient outgrowth of cells is obtained, usually after 7-10 days of incubation.
6. Treat the exponentially growing cells with 0.1 µg/ml Colcemid for 4-8 hours at 37-39°C, dislodge the cells by trypsinization (0.25% trypsin solution, 10-15 minutes, 37°C), and collect the cells by centrifugation (1,200 rpm, 5 minutes).
7. Apply steps 5-10 of the blood culture method described above. The volume of the fixative for the final cell suspension should be changed according to the volume of cell pellet.

KARYOTYPES IN GRUIFORMES

Using these methods, mainly the blood culture, we have checked the sex of some 200 birds during the past decade; some of the cultures were sent abroad, e.g., New York Zoological Society and Oklahoma Zoo. We have examined 116 cranes of 10 species. We analyzed karyotypes of cranes and some related species, i.e., seriemas (Cariamidae) and trumpeters (Psophiidae), each belonging to a different suborder or a superfamily in Gruiformes (Table 2).

As in mammals, closely related species possess identical or very similar karyotypes. A feature characteristic to birds is that karyotypes often resemble each other in species belonging to widely divergent orders (Fig. 3). Though data are still meager, it seems likely that the basic pattern of an ancestral bird karyotype has been preserved after divergence of major orders. Karyotypic resemblance in certain phylogenetically remote species, on the other hand, might have resulted from similar but independent chromosome rearrangements. One has to exercise caution, there-

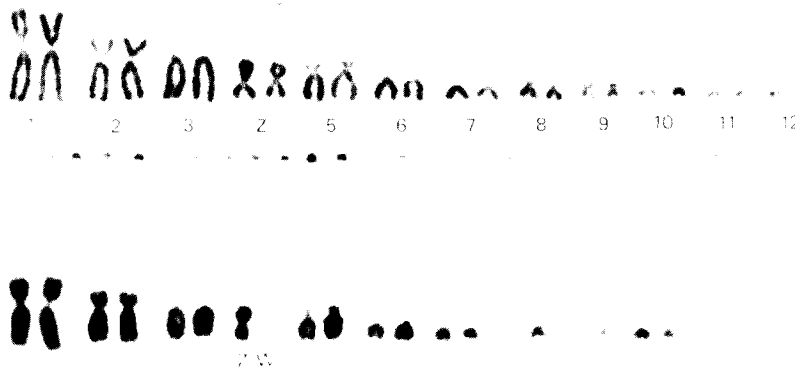


Fig. 2. Sex chromosomal difference between the male (above, ZZ) and female (ZW) domestic chicken.

Table 2. Cranes and related birds successfully sexed at Chromosome Research Unit, Hokkaido University, Sapporo, Japan.

Species	Number of birds	
	Female	Male
European crane (<i>Grus grus</i>)	6	3
Sandhill crane (<i>G. canadensis</i>)	1	3
Red-crowned crane (<i>G. japonensis</i>)	4	3
Sarus crane (<i>G. a. antigone</i>)	5	4
Hooded crane (<i>G. monacha</i>)	7	5
White-naped crane (<i>G. vipio</i>)	9	12
Demoiselle crane (<i>Anthropoides virgo</i>)	7	6
Stanley crane (<i>A. paradisea</i>)	4	9
Crowned crane (<i>Balearica p. pavonia</i>)	4	3
West African crowned crane (<i>B. p. regulosum</i>)	1	6
Wattled crane (<i>B. carunculatus</i>)	8	3
Grey-winged trumpeter (<i>Psophia crepitans</i>)	2	2
Pale-winged trumpeter (<i>P. leucoptera</i>)	1	1
Dark-winged trumpeter (<i>P. viridis</i>)	1	0
Black-legged seriema (<i>Chunga burmeisteri</i>)	1	1
Total examined	63	62



Fig. 3. Karyotypic resemblance between remotely related species of birds: (a) emu, (b) Humboldt penguin (*Spheniscus humboldti*), (c) European white pelican (*Pelecanus onocrotalus*), (d) eastern white stork (*Circonia c. boyciiana*), (e) northern screamer (*Chauna chavaria*), (f) greater flamingo.

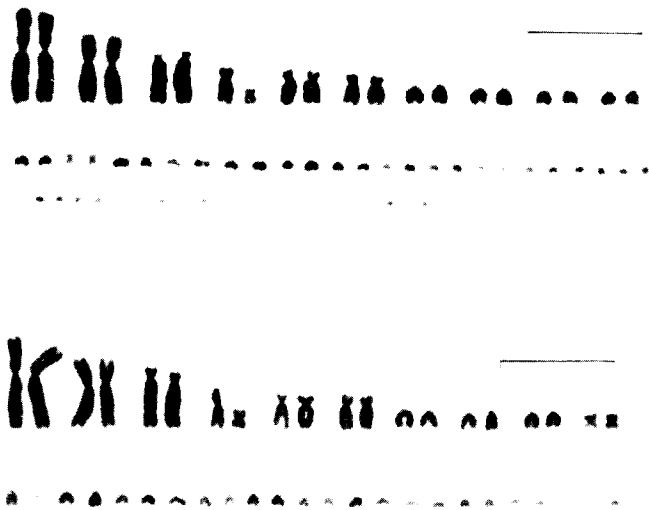


Fig. 4. Full karyotypes of the wattled crane (*G. carunculatus*, above) and king vulture (*Sarcorhampus papa*). It is almost impossible to distinguish these species karyotypically.

fore, in the interpretation of karyotypic data in birds. Further information and more exhaustive accounts on these problems are referred to in some of the recent literature (Hammar 1970, Takagi and Sasaki 1974, de Boar 1976).

Cytogenetic studies in Gruiformes are of interest in view of the extreme phylogenetic heterogeneity of the taxa. All species of cranes studied have typical bird karyotypes which are almost indistinguishable from each other and from those of such phylogenetically remote species as condors and flamingos (Fig. 4). The karyotypes of the 3 species of trumpeters (*Psophia*



Fig. 5. Partial karyotypes of the Andean condor (*Vultur gryphus*), sarus crane (*G. antigone*), demoiselle crane (*Anthropoides virgo*), and grey-winged trumpeter (*Psophia crepitans*).

crepitans, *P. leucoptera*, and *P. viridis*, Table 2), are identical and very similar to those of cranes (Fig. 5) and gallinules belonging to the Rallidae, although the diploid chromosome is 92 in coot (*Fulica atra*, Hammar 1970). Karyotypic differences between trumpeters and cranes may be explained by 3 or 4 pericentric inversions and a few translocations. On the other hand, the black-legged seriema (*Chunga burmeisteri*) is unique in having an entirely different karyotype with about 110 chromosomes (Fig. 6a). Curiously enough, this karyotype closely resembles that of toco toucan (*Rhamphastos toco*, Fig. 6b) belonging to Piciformes. Detailed accounts of the karyotypic profiles of these species will be published elsewhere (Takagi and Sasaki 1980). We do not know whether this karyotypic heterogeneity in Gruiformes reflects inadequateness in the present classification system.

Recently developed chromosome banding techniques are promising to shed more light on the aforementioned problems, although not many avian species have yet been examined by banding. Fig. 7 is an example of banded chromosomes from a white-naped crane (*Grus vipio*). Each chromosome now shows a characteristic pattern of banding along the longitudinal axis of each arm by which the identification of homologues is made very precisely, and even part of the chromosome arms can be compared to trace the origin of certain morphologically rearranged chromosomes during evolution processes. Such attempts have been made in various mammalian, as well as in a few avian, species, but not in the crane (Stock et al. 1974, Takagi and Sasaki 1974). The difficulty in determining the exact number of microchromosomes, however, will be overcome to a certain



Fig. 6. Apparent karyotypic resemblance between the black-legged seriema and toco toucan.

extent by the C-banding technique, which specifically stains the constitutive heterochromatin near the centromere of chromosomes (Fig. 8). These and some other new banding techniques are being applied by us to clarify the karyotypic problems in Gruiformes and Aves.

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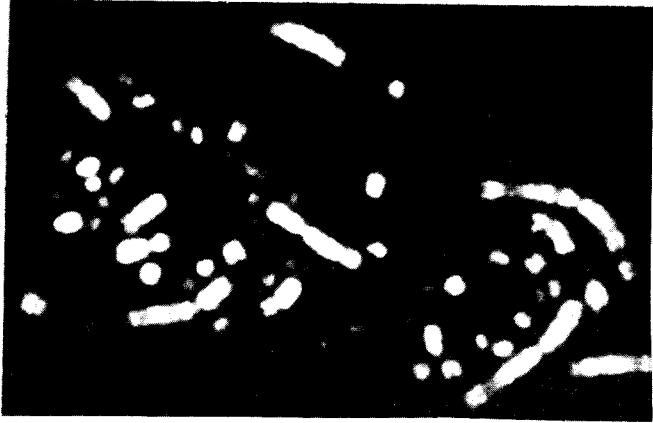


Fig. 7. An R-banded metaphase spread from a whitenaped crane. Bands were visualized by acridine orange fluorescence microscopy after incorporation of 5-bromodeoxyuridine.



Fig. 8. A C-banded metaphase spread from a whitenaped crane.

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Sandhill Crane



Florida sandhill crane at nest (photo by L. Walkinshaw).

THE SANDHILL CRANES

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The following report is a result of 50 years of study of the 6 subspecies of sandhill cranes (*Grus canadensis*) by the author, plus the work of many others, most of them doing their work in the past decade.

The sandhill crane is a large gray North American bird which stands 1 to 1.5 m tall and weighs 3,400 to 6,000 g. It has a bare red forehead. Normally its plumage is gray but breeding adults often change this coloration by decorating their feathers with soil, vegetation, or water stained with ferric oxides. Thus many individuals become a beautiful reddish-brown. Fossil remains of this bird have been found from the Pliocene of Nebraska and from the Pleistocene of California, Florida, Wyoming, Nebraska, and Illinois (Walkinshaw 1949:128) and it may have bred as far south as the Valle de Mexico, a century ago. The birds are presently found from northeastern Siberia eastward to Baffin Island then south to central California, parts of Central Mexico eastward to Michigan, Florida, Cuba, and the Isle of Pines.

Although the birds normally show fear of predators and man, they can become quite confiding if undisturbed. They prefer isolation when nesting, roosting, and feeding. During the breeding season they are strongly territorial but since they have been known to live many years, even up to 30, and because they normally mate for life, they use the same territory for many years without conflict with neighboring cranes. They build ground nests of nearby vegetation, 0.5 to 1 m across within their territory. Many nests are placed in shallow water (5 cm up to 1 m deep) where the natural dead or live vegetation is good cover and the bird's reddish-brown and gray plumage provides excellent protection. Like other *Grus* the female normally lays 2 eggs (2 days apart), rarely 1, and more rarely 3. Eggs vary in size, according to the subspecies, from 75 to 110 mm in length, 50 to 65 mm in width, and weigh from 115 to 220 g. They are normally ovate-shaped. Incubation requires between 30 and 32 days.

The chicks are covered with beautiful tawny brown down when they hatch. Within 24 hours they are capable of walking, wading, and swimming. They begin a nomadic life with their parents but generally remain on or near their former territory in their relentless search for food. They eat many types of food: bulbs, roots, grass seeds, berries, tundra plants, earthworms, insects including grasshoppers and crickets, snails, crayfish, mice, lemmings, even eggs and small birds. In the Arctic, chicks fly when about 45-50 days of age but farther south not until they are 60 to 75 days old. Often 1 sibling, even at hatching, is dominant over the 2nd and attacks it relentlessly; this sometimes leads to the death of 1 chick. But other pairs produce 2 flying youngsters because 1 parent takes 1 chick and the other parent the 2nd.

When the young begin to fly, the family group still remains intact until the next breeding season. Then the parents drive them away and re-nest. Twice in Florida many pairs did not nest because of extreme drought and once in Michigan's Upper Peninsula I found many pairs did not nest because snow covered the breeding marshes at the season when they normally laid eggs. In the fall, winter, and spring the northern

subspecies are often very gregarious, at times forming immense flocks.

Six subspecies of sandhill cranes have been described of which 3 are migratory and 3 are not.

THE LESSER SANDHILL CRANE

Calling this bird the "Brown and Ash-coloured Crane," Edwards (1750) gave the original description for *Grus canadensis canadensis* from a specimen taken along Hudson Bay. It is migratory and breeds from northeastern Siberia eastward across Alaska, northern Canada including Banks and southern Victoria Islands southward to Churchill, Manitoba, more rarely as far as Baffin Island, to the east. Its main breeding grounds are northeastern Siberia, western Alaska, and northern Canada where daylight is continuous, and the habitat is tundra. I have observed 9 of their nests (Fig. 1). One nest, 8 June 1946 about 800 m west of the Johnson River, west of Bethel, Alaska, was placed on the flat top of a steep peninsula which jutted out into the lower water-soaked tundra. In the same region the next day another nest was found in the flat bottom of a narrow, steep ravine. Three nests were then found 20-21 June 1946 near Old Chevak a few hundred meters back from the Kashunuk River. All were placed in naturally hollowed spots in the tops of steep dirt mounds on the tundra. Four nests near Sachs Harbour, Banks Island, 13, 13, 16, and 19 June 1964 were also built on steep sand mounds. All were in extremely dry situations but very near water.

Similar nests were found by Brandt (1943) and Boise (1976:128, 1979:22) but some were found in shallow water in marshy situations. Boise wrote, "Overall nesting density was 0.7 nests per km², the shortest distance between 2 nests was approximately 1,700 m." while the files of Clarence Rhode National Wildlife Refuge for 1967-1971 indicated a nest density of 1.3 nests per km². On Banks Island I found 7 pairs between my camp and Fishing Lakes, from the Beaufort Sea to the Sachs River, approximately 115 km² or 1 pair every 16.5 km². The 2 closest nests were slightly over 1 km from each other while a 3rd pair was shot by Eskimos about the same distance from both of them.

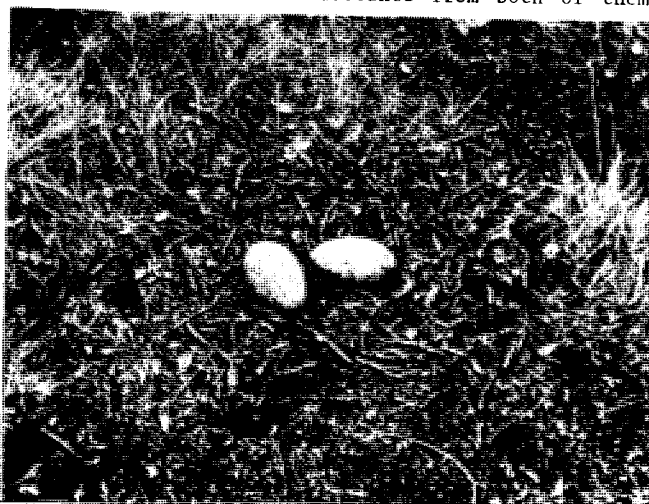


Fig. 1. Lesser sandhill crane nest on Banks Island, Canada.

Nests were located where dry but 5 to 20 cm below each the ground was frozen solid. All of these dryland nests were skimpy, constructed of only a few pieces of grass, sedge, or willow (*Salix* sp.). Nine Arctic nests averaged 40.1 (35.5-50) by 42.6 (36-53.3) cm across and, in most, the eggs rested on bare ground.

I gave records (1973:104) of 87 clutches found across the Arctic, averaging 1.87 (76 of 2; 11 of 1) eggs per clutch. Boise (1976:128) gave records of 71 clutches which averaged 1.76 (54 of 2; 17 of 1) eggs per clutch on the Clarence Rhode National Wildlife Refuge. Measurements of 91 Alaskan eggs averaged 90.8 (77.4 to 101.0) by 57.5 (44.0 to 63.2) mm; 8 eggs from Banks Island were smaller, averaging 86.2 (82.4 to 90.0) by 54.9 (52.1 to 57.1) mm. Average weight of 7 eggs was 133.7 g (119.9 to 146.5) but they were weighed during different periods of incubation. Brandt (1943) wrote that the normal shape was elongate ovate or ovate but a few were pyriform, elliptical ovate, and even cylindrical ovate. Boise (1976:128) reported 1st chicks 14-15 June, while the latest hatched 1 July 1975, and 1st flights of young on 11 August. Eggs in western Alaska had not hatched by 21 June 1946 nor had those on Banks Island by 1 July 1964.

Boise (1979:229-236) showed that Alaskan cranes, banded before they were old enough to fly, were recovered in 1976, the year they were banded, on 5 October at Batrum, Saskatchewan; 23 and 25 October in Terry County, Texas; and 11 November at Bitter Lakes, New Mexico. In 1975 one was found near Roswell, New Mexico 31 October, another in west-central Mississippi, 12-15 December (possibly lost from parents), and at Lagunitas, Chihuahua, Mexico, 27 December. Two-year-old young were found in late March and early April 1978 in Buffalo and Lincoln Counties, Nebraska, and one 1976 bird was found from 28 April until 10 May 1977 at Spring Valley, Saskatchewan. Another bird was found at Stevens Point, Wisconsin. None of the 2-year-olds were found nesting but some were mated. Huey (1965) reported a bird banded in winter in New Mexico was found in summer in Siberia. Wheeler (Wheeler and Lewis 1972) banded 542 sandhill cranes along the Platte River, 1965-1968. Recoveries were reported from Wadena, Saskatchewan; Madera, Chihuahua, Mexico; Delta Junction, Alaska; Bula, Littlefield, and Big Spring, Texas; and Tuktoyaktuk, Northwest Territories, Canada.



Fig. 2. Canadian sandhill crane pair.

Lesser sandhill cranes leave Alaska by late August or September crossing to western Alaska from Siberia and from Banks Island to the Canadian mainland in late August then to central Alaska where they depart later in September or early October. Some reach Saskatchewan in mid-August and the flock reaches considerable size by early September. Munro (1950) reported concentrations occurred there between 1 August and 19 October (1945-1947) and Stephen (1967) reported concentrations between 9 August and 30 October (1960-1963) with the peaks of about 18,000 between the 3rd week in August and mid-September. Probably the last birds do not reach the wintering grounds until late November or early December. The wintering region extends from southern California across to eastern Texas and south in Mexico, sometimes as far south as Mexico City (Walkinshaw 1949, 1973b). The chief wintering grounds are western and southern Texas, northern Chihuahua, and eastern New Mexico.

The American Ornithologist's Union (1944:633) listed a total of 100,000 lesser sandhill cranes. They had increased some since the establishment of many National Wildlife Refuges in the United States. This population (Drewein et al. 1975) plus the Canadian crane reached 265,000. Buller (1979:5) gave the spring population surveys in Nebraska, 1959-1978 as follows: 20 March 1959, 147,496; 4 April 1960, 125,870; 21 March 1961, 136,276; 21 March 1962, 142,830; 21 March 1963, 101,925; 30 March 1964, 156,028; 30 March 1965, 80,315; 25 March 1966, 123,087; 23 March 1967, 123,043; 22 March 1968, 169,194; 2 April 1969, 154,978; 26 March 1970, 193,600; 28-29 March 1971, 207,500; 27-28 March 1972, 183,600; 26-29 March 1973, 195,350; 25-31 March 1974, 177,015; 25-30 March 1975, 227,527; 25-26 March 1976, 153,784; 17-19 March 1977, 219,154; and 22-24 March 1978, 159,898.

THE CANADIAN SANDHILL CRANE

Grus canadensis rowani migrates northward across Nebraska in March and early April and across Saskatchewan in late April. In mid-August it begins to migrate southward. In spring it is found more abundantly farther east in Nebraska than *G. c. canadensis* and in autumn more are found farther east in North Dakota and in western Minnesota. It nests in the boreal forest regions of central Alberta, Saskatchewan, Manitoba, northern Ontario, and probably central British Columbia. It winters farther east than the majority of *G. c. canadensis*, more in eastern Texas. There is a specimen (Royal Ontario Museum of Zoology) from Cameron Parish, Louisiana. It is found to a lesser extent in western Texas and eastern New Mexico and probably some in northern Mexico.

First described by Walkinshaw (1965:181-184), it is intermediate in size between the lesser and greater sandhills (Fig. 2). Also described by Johnson and Stewart (1973) and Aldrich (1979), this bird has a longer tarsus and shorter wing than *G. c. canadensis*, and a shorter wing and bill than *G. c. tabida*. The type specimen is a male, taken by William Rowan 1 June 1943 16 km west of Fawcett, Alberta (wing, 524 mm; tarsus, 222 mm; exposed culmen, 118.3 mm; bill from tip to posterior of nostril, 85 mm).

The bird roosts in shallow water at night, feeding after daylight in open pasture, hay, or grainfields. In the fall it may cause damage to spring wheat in Saskatchewan and eastern North Dakota. It nests in extensive muskeg regions of the boreal forests of Alberta, Saskatchewan, Manitoba, and to a lesser extent in northern Ontario. The chief local plants are

sphagnum moss, leatherleaf (*Chamaedaphne calyculata*) bulrushes (*Scirpus validus*), grasses, and sedges (*Carex* sp.), all growing in water-soaked regions. The bogs are often surrounded by solid stands or scattered black spruce (*Picea mariana*) and tamarack (*Larix laricina*) forests or partially by their dead remains while occasional high ridges contain jack pine (*Pinus banksiana*), some white birch (*Betula papyrifera*), aspen (*Populus* sp.), some willows (*Salix* spp.), and other shrubs (Baker and Walkinshaw 1946). Open marshes, their 2nd nesting habitat, are often bordered by these same forest types. In southern Saskatchewan these marshes can still be found.

In the bog regions nests are very skimpy. The birds build them much like the lesser sandhill in the Arctic. In the open marshes they build nests of bulrushes, sedges, and grasses, a huge pile in shallow water. I found such a nest in the buffalo corral near Ft. Smith, Northwest Territories, Canada, 4 June 1964. It was a pile of dead bulrushes and *Carex* in 30 cm of water, well out in an open marsh. It measured 62 by 69 cm across, was nearly flat on top, built well above the surrounding water, and isolated by the past year's emergent bulrushes, grasses, and sedges. On 3 June 1964 when the Canadian Wildlife Service flew me over the whooping crane (*G. americana*) nesting region, we noted whooping cranes were nesting in shallow water, well out in the marshy ponds from shore, but sandhills were nesting in drier boggy situations.

In the central Alberta bogs I found a sandhill crane sitting on an egg on a grassy island without a nest and B. W. Baker found another nest, 2 days later (22 May 1942), which was built on a dry ridge. It consisted of 40 to 50 short twigs pulled from nearby dwarf birches and a few wads of sphagnum moss. It measured 80 by 60 cm across. The ridge, about 1 m wide, was 1 of many crisscrossing ridges scattered haphazardly through a treacherous bog. Even in early June many ridges still had ice below them.

I wrote (1973b:109): "Egg records from western central Canada ranged between April 11 and July 1. There were five sets of one egg; 48 of two eggs (mean 1.91). The average measurement of 22 eggs from Alberta, Saskatchewan, and Manitoba was 91.69 (85.3-102.0) × 59.27 (54.6-65.0) mm." Three eggs at Fawcett, Alberta in late May 1942 measured: 95.5 by 60.5, 99 by 62, and 96 by 60 mm and weighed 190, 170, and 159.1 g. Ovate in shape, they were colored and marked much like lesser and greater sandhill eggs, sparingly marked with brown, gray, and lavender.

We found 2 chicks at Fawcett, Alberta, 30 May 1942 (1 just hatched) colored the same dark tawny brown all over with darker regions down the posterior like other sandhill cranes but darker than Florida sandhill cranes. I found 2 chicks on the nest at Ft. Smith, Canada, 4 June 1964. The remains of egg shells on the nest indicated 1 had just hatched. These 4 newly hatched chicks averaged 107.8 (the 2 newly hatched ones averaged 104.8 [97.8 to 111.8]) g; their wings averaged 37.4 (30 to 46.5) mm; their tarsi, 43.2 (37 to 49) mm; exposed culmen, 22.8 (21 to 24.8) mm.

Aldrich (1979:144) stated: "Canadian sandhills number about 54,000 of which 18% are young of the year. Approximately 4,500 were killed by hunters in 1977, or 29% of the total sandhill crane hunting mortality, and about 7% of the total Canadian sandhill crane population." Lewis (1974:20-30) reported specimens of *G. c. rowani* were taken in spring at the 4 most eastern regions along the Platte River, Nebraska, but they were greatly outnumbered by *G. c. canadensis*

at all except the most eastern location at Alda where 5 out of 6 were referable to *G. c. rowani*. These were intermixed in the tremendous spring concentrations there in March and April. Buller (1976:78) reported that 17% of the Canadian sandhill cranes he censused in the central United States in 1974 were young. Johnson (1976) stated that Canadian sandhills were found in the central part of North Dakota, the lesser sandhills farther west, and the greater sandhills farther east.

Johnson (1979), using data secured from Buller (1979), discussed the impact of sport hunting on the sandhill crane populations. He statistically used 4 types of data: (1) spring population size; (2) fall age composition, estimated from 1974-1976 figures to be 11.3% young; (3) annual harvest, about 5 to 7%, based on several sources; and (4) age composition of harvested cranes. He found immatures were 2 to 4 times more vulnerable to hunting. He tried 738 population models of which 37 yielded population sizes and age structures comparable to those in real populations. In all combinations a decline of 5 to 54% of the crane population occurred. The median decline was 22%, indicating the total hunted population would be about 75% as large as a nonhunted one.

THE GREATER SANDHILL CRANE

An adult male *G. c. tabida* was taken 19 May 1859 by Charles McCarthy in the Valley of the South Fork of the Humboldt River, Nevada. It is in the Museum of Comparative Zoology, Cambridge, Massachusetts. First described by Peters (1925:142), it is the largest of the sandhill cranes. In size it resembles the Florida subspecies but it has a light mouse-gray occiput; on *G. c. pratensis* it is dark mouse-gray. Their ranges overlap only during the winter.

The breeding birds from Oregon and northeastern California, and probably those from Washington and British Columbia, winter in the Central Valley, California (Littlefield and Thompson 1979); those from Nevada apparently winter near Poston, Arizona (Drewien et al. 1976); the Idaho, Wyoming, Montana, and Colorado birds apparently winter chiefly at Bosque del Apache National Wildlife Refuge, New Mexico; central Manitoba birds go to eastern Texas; possibly southern Manitoba birds may go to Florida; the Eastern population birds (Minnesota, Wisconsin, Michigan) winter in north and central Florida.

Little is known about the present status in southern British Columbia and Washington but several pairs are known to breed at Pitt Meadows, British Columbia. Littlefield and Thompson (1979) summarized the occurrence and abundance of the western population: "The Central Valley population . . . consists of 3,000 to 3,200 birds which nest in eastern Oregon and northeastern California. In Oregon they nest in Malheur, Harney, Lake, Grant, Baker, Union, Deschutes, and Klamath Counties and in California in Modoc, Lassen, Siskiyou, Sierra, Plumas, and Shasta Counties. Lake and Harney Counties, Oregon support the largest number of nesting pair . . . A large percentage of the population (2,300 to 3,000 individuals) congregates on Malheur National Wildlife Refuge, Harney County, Oregon, before migrating in the fall. After leaving the refuge they fly southwest to the Central Valley of California. In spring they follow the same migration route. Their wintering area extends from 13 km southeast of Chico, Butte County, California, south and east to near Delano, Tulare County, California. The largest number winter 5 km south of Thornton in San Joaquin County."

Concerning the Nevada population, Drewien et al. (1976) wrote: "Two subspecies of sandhill cranes . . . are known to occur in Nevada; the lesser (*G. c. canadensis*) as an uncommon migrant and the greater (*G. c. tabida*) as a migrant and summer resident. In western Nevada, cranes occur only in small numbers and mainly as spring and fall transients. Our surveys for 1971-1975 show that the principal nesting range of the greater sandhill cranes is Elko County in northeastern Nevada, where cranes occur from March-October . . . flightless young captured and color-marked in Elko County show that they utilize the Lund (eastern Nevada) staging area and winter along the Colorado River near Poston, Arizona . . . observations at the Arizona wintering grounds, the Lund staging site, and of migrants in the Pahranaagat Valley indicate a total population of over 1,000." They considered this population separate from those in both Oregon and Idaho.

Drewien (1973) wrote about the species: "Most nest from northeastern Utah, northward along the Idaho-Wyoming border to southwestern Montana. An estimated 250 pairs nest at Grays Lake, Idaho, of which 200 pairs nest within an area of 10,000 ha. A total of 337 nests were found, most in wet-meadow-shallow marsh zones along the marsh edge. Nesting occurred from late April through early July . . . Fall flocks contained 16 juveniles per 100 adults . . . mean size of five territories was 17 ha. Most daily requirements are found within territories and some families occupy territories for five consecutive months during the annual cycle. Young fly at 67-75 days. Gregariousness begins in August as young start flying . . . The Rocky Mountain Greater sandhill crane population was estimated at 10,000-15,000."

Drewien (1973) found the birds in spring and fall migration in eastern Utah and western Colorado; the only major stopover was in the San Luis Valley, Colorado, and the majority wintered at the Bosque del Apache National Wildlife Refuge, Socorro County, New Mexico, but a few had been found in western New Mexico, southeastern Arizona, and Mexico.

Bieniasz (1979) studied the summer population in Colorado. She estimated 250 sandhill cranes were found in Routt, portions of Moffat, and Jackson Counties. This breeding region consists of willow-dotted streams bordered with sagebrush parks.

D. Johnson (1976) reported a flightless juvenile sandhill crane in the summer of 1973 at the J. Clark Salyer National Wildlife Refuge, North Dakota, the 1st positive breeding record for North Dakota for many years. J. Johnson (1976) and Grewe (1977), from their own work and that of Carroll Henderson, reported 67 breeding pairs in Minnesota (in Anoka, Aitkin, Beltrami, Chisago, Kanabec, Lake of the Woods, Mahnomon, Marshall, Mille Lacs, Morrison, Kittson, Pine, Sherburne, Pennington, Polk, and Roseau Counties); during their 1977 survey they found 149 nonbreeders, 67 pairs which reared 50 young (0.74 young/pair). Thus 15% were birds of the year.

Hunt and Gleusing (1976), Bennett (1978), and Howard (1977) did considerable work on the species in central and southeastern Wisconsin. Hunt and Gleusing (1976) considered the Wisconsin population around 1,000 birds while there were 250 pairs in 1973 nesting in 32 counties. During 1979 a flightless young sandhill crane was found in northeastern Illinois, the 1st record apparently for this century, and Mark Weldon found a nest in 1978 and another in 1979 only 30 m from the Indiana line. The last Indiana nest was found in 1929.

William Taylor (1976, 1977) estimated 130 pairs of cranes in 218 square miles (56,486 ha) in the Upper Peninsula of Michigan; 1,800+ cranes were counted in 15 locations in the eastern half of the Upper Peninsula. Taylor (pers. comm.), by use of a helicopter, found 43 nests in 1978 and 47 in 1979 on the Hiawatha National Forest. Walkinshaw (1978) recorded crane nests from Alger, Baraga, Chippewa, Delta, Luce, Mackinac, and Schoolcraft Counties. Both Taylor and Walkinshaw commented on the increase of greater sandhill cranes in the Upper Peninsula. This increase was also reflected by the spread into contiguous regions in nearby Ontario where Tebbel and Ankney (1979), searching by helicopter, found 157 cranes and considered the actual population much higher. They observed 4 nests and 11 pairs with young. These birds had moved into these regions during the past decade. Cranes similarly moved into Cheboygan County (northern tip of Michigan's Lower Peninsula) where E. Voss (letter) found a pair with a chick, in 1963 and possibly as far south as Mason County where I found a nest with 2 eggs in 1974 and also observed cranes in Marquette County.

In 1978 I reported that cranes in the Upper Peninsula used the sphagnum moss-leatherleaf bogs, and less often the sedge marshes, in contrast to open marshes used in the Lower Peninsula. During the 1930's I found very few cranes in Michigan and they were using the larger bogs and marshes. Gradually they have moved into smaller wetland regions, using several that were 4.8 ha or smaller. The marshes previously used varied between 324 and 810 ha. Upper Peninsula nests (mean size 60.1 by 68.4 cm across; 5.4 cm high) were built of sphagnum moss and dead black branches pulled from nearby leatherleaf and Labrador tea bushes. Fifty-nine percent of 49 nests had no standing water beside them but all were surrounded by water ranging from 2 cm to 3 m or more, and some of these acid bogs (with a pH of 5.0 or lower) were very treacherous. All were isolated and no nest was found near a well-traveled highway, even though some were found near less traveled dirt and gravel roads. Taylor found a similar distribution of the nests he located by helicopter.

I began my sandhill crane studies in the Lower Peninsula of Michigan in 1930. With the exception of 1934, I have seen sandhill crane nests, every year since then, a total of 256 nests located in Mason (2), Clinton (11), Shiawassee (1), Barry (5), Eaton (8), Ingham (1), Livingston (7), Kalamazoo (3), Calhoun (42), Jackson (159), Washtenaw (13), St. Joseph (2), and Branch (2) Counties. Whereas I was fortunate to find a single nest during a year's time in the 1930's, I found 27 nests in Michigan in 1973. Ron Hoffman and I have found as many as 6 or 7 nests during some years in the Haehnle Sanctuary during the past 8 years. Ron Hoffman (1977) has found between 140 and 150 nests in northeastern Jackson and northwestern Washtenaw Counties. And during the past 2 years Mark Weldon has found nests in the southern tier of Michigan counties.

During this period at least 4 large marshes have been drained for agricultural purposes. They were the Chandler Marsh, Clinton County; an Iosco Township, Livingston County marsh; another between Imlay City and Capac in Lapeer and St. Clair Counties; and a large section of the Springsport marsh, Jackson County. Many marshes were drained in the past, including the large Henrietta Marsh, Jackson County, and several in Calhoun and Eaton Counties. But the southern Michigan population has increased steadily since 1930. This is evidenced by the size of fall flocks found in both Jackson and Calhoun Counties.

Similar increases have been demonstrated throughout the Eastern population of the greater sandhill crane as is evidenced by the tremendous increase of cranes at Jasper-Pulaski Game Area, Indiana, from 35 birds in 1935 to a fall peak of around 14,000 in 1978 and 1979. At Haehnle Sanctuary and nearby Waterloo marshes, fall flocks numbered about 40 birds in 1940. Harold Wing, Ron Hoffman, and others have found as many as 900 in the past 2 years. At Baker Sanctuary I found 16 birds in October 1941; Mabelle Isham found 130 in November 1979 while we found 50 cranes in Oceana County in late September 1979. The count of fall groups in 1979 totalled around 14,000 birds, which is probably an underestimate of the total. Breeding surveys have been periodically made in southern Michigan since 1952. Where I estimated 17 pairs were breeding in 1931, and 27 pairs in 1947, Harold Wing and I, with the cooperation of many others, found 49 pairs in 1952. Powell and Betty Cottrille and I found a few additional pairs (1956-1957) and Hoffman and I found 158 pairs (1971-1973).

Nests during the 1930's were in the largest surviving marshes. Although these are still used, we often find cranes nesting now in marshes of 5 to 8 ha, sometimes within 10 m of dry land. In the Baker Sanctuary (1931-1964) the average distance (measured on an aerial photograph) of 26 nests from shore was 238.6 ± 257 m and the nearest woods was 144.2 ± 86.4 m. Many nests could not be seen from any nearby point, they were so well isolated. Now at Haehnle Sanctuary crane pairs show various responses to human intrusion but we have found many nests (Fig. 3) by watching from a nearby hillside. Some of these nests are on the very edge or within 10 m of an open pool. Although 7 pairs nested in 260 acres in 1 year at Haehnle Sanctuary, a maximum of only 2 pairs have nested in 390 ha of Baker Sanctuary and we have not yet found more than 1 pair in smaller marshes. Pairs nesting in small marshes often feed on high ridges, or corn, wheat, pasture, alfalfa, timothy, or clover fields.

Crane pairs at Haehnle Sanctuary remain on their territories most of the time between May and September. Cranes sometimes arrive in southern Michigan in late February but some return in March and remain until October, November, and sometimes even December. Rarely a few individuals remain throughout the winter. Breeding pairs go immediately to their past year's territories and egg-laying begins in late March or during April. The earliest Hoffman and I have found newly hatched chicks was 23 April but most eggs hatch the first 2 weeks of May. Mild weather accelerates nesting; cold weather somewhat retards it.

Southern Michigan nests are normally well hidden by the previous year's emergent vegetation--cattails (*Typha latifolia*), bulrushes (*Scirpus validus*), loosestrife (*Decodon verticillatus*), several species of sedges (*Carex*), and grasses (*Andropogon* and others). Nests are built of the nearest dead plants. Among 251 nests, 108 (43%) were built chiefly of dead cattails, 67 (26.7%) of sedges, 48 (19.1%) of bulrushes, 19 (7.6%) of loosestrife, and 9 of other plants including *Sparganium eurycarpum*, and grasses. These nests were larger than nests in Upper Peninsula bogs. The mean measurements at water level were 130.1 by 101.5 cm with the top from 25 to 35 cm across, resting 13.0 (1.5 to 31 cm) above standing water which measured from 0 to 3 or 4 m deep where some nests were built over quaking bogs. Only a few nests have been found on dry mud islands 2 or 3 m in width; all the rest have been placed in shallow water. Many were almost flat but some were depressed about 3 cm in the center for eggs.



Fig. 3. Adult greater sandhill crane at nest.

Both parents helped build nests and both birds shared incubation duties. Eggs were generally laid 2 days apart while incubation required between 28 and 32 days (mean 30). Eggs generally hatched on the same or consecutive days. The female normally incubated at night while the male stood a few meters away in shallow water. Both male and female had favorite night roosting spots, often well hidden by bushes or tall vegetation. The mean measurements of 259 southern Michigan eggs were 94.0 (86.0 to 108.0) by 60.3 (54.5

Table 1. Causes of loss of greater sandhill crane eggs and young.

Cause of loss	Nests lost	Eggs lost	Young lost
Deserted	11	21	3
Eggs disappeared	1 ^a	2	
Broken egg		1	
Flooded	3	2	3
Infertile eggs or eggs that failed to hatch	14 ^b	41	
Crow	1	1	
Raven	2	4	
Other predator	11	26	
Young died			2
Unknown	2	6	2
Total	45	104	10

^aA man's tracks led to and from this nest and I believe he took the eggs.

^bIn 14 nests all 24 eggs failed to hatch (10 nests of 2 eggs, 4 nests of 1 egg); 1 egg failed to hatch in each of 17 nests where 2 eggs were laid.



Fig. 4. Fifty-three-day-old greater sandhill crane.

to 65.6) mm and the mean weight when newly laid was 192.6 (174.3 to 214.7) g, while 72 Upper Peninsula eggs averaged $91.8 \pm \text{SD } 6.25$ (76 to 104) by $60.2 \pm \text{SD } 3.1$ (51.8 to 65.2) mm. Two fresh eggs weighed 175 and 216.3 g. The average of 47 clutches in the Upper Peninsula was 1.96 eggs per clutch (2 of 1; 45 of 2) while 246 Lower Peninsula clutches averaged 1.94 (15 of 1; 230 of 2; 1 of 3) eggs.

In the Upper Peninsula 18 nests were studied until their eggs hatched or were lost to predators; 12 were successful (66.7%). Among 33 eggs in these nests, 23 chicks hatched and left the nest (69.7%). In the Lower Peninsula, eggs hatched in 161 of 204 nests and young fledged from 157 (76.9) nests; 380 eggs were observed of which 294 hatched and 284 fledged (74.7%).

The mean Upper Peninsula hatching date was 22-23 May ranging between 16-17 May and 27-28 May. In 1 bog, two 2-egg clutches were lost, apparently to ravens because the eggs were found nearby with large bill holes in them and ravens were prevalent there. One pair renested and their chick hatched 23 June.

The mean for 89 Lower Peninsula hatching dates was 11-12 May. Up until 1970, the mean was 13-14 May but during the 1970's it was 9-10 May, with the earliest date 23-24 April along with several other late April hatching dates, indicating that when the temperature was warm eggs were laid late in March. Known losses of eggs and chicks are shown in Table 1. Young cranes surviving the summer to flight state (Fig. 4) were recorded during several summers (Table 2).

In autumn the Eastern sandhill crane population concentrates in the evening in large marshes where there is no human intrusion. Here large flocks sleep, standing in shallow water throughout the night. From break of day for the next hour groups leave these roosts for nearby fields, 1 to 6 km or farther away. Some feed on alfalfa, some in pasture or hay fields, but during late August and September they often feed in wheat fields, at first where it has been harvested, then later on newly planted fall wheat. Later in the fall they feed more on corn, showing a preference for this grain. Much of the grain they eat is unharvestable, but at times they especially damage wheat. Flocks of nonbreeders may do much harm to newly planted corn in spring.

In October, November, even into early December, these birds depart for their winter home in Florida. I first described this behavior (1960), and then Williams and Phillips (1972) marked several cranes in winter in Florida that were later found in Manitoba, Wisconsin, and Michigan; and, later, radio transmitters were placed on some and they were followed by Crete and Toepfer (1978) from Minnesota, through Wisconsin to Jasper-Pulaski Game Area in northern Indiana across Kentucky, Tennessee, and Georgia to northern and central Florida. Crete and Toepfer (1978) and Toepfer and Crete (1979) found 14 of 15 birds in 7 different Florida regions. These birds spent the nights on the ground, some near Muscatatuck River 26 km SW of Seymour, Indiana; some near Somerset, Kentucky; and then north of Chattanooga, Tennessee. Thus, 3 overnight stops were used, but these birds were handicapped by radios, and Tacha (1979) has shown that even placing bands and streamers on cranes changes their behavior so that some birds even left their family groups for periods of up to 3 months. Toepfer and Crete (1979) found their birds returned to Minnesota and Wisconsin the next summer and found some back in Florida again the next winter. But by banding and radios we have learned a great deal about their migrations and winter distribution.

With the aid of many observers, the present greater sandhill crane population can now be estimated more accurately than ever before. The total does not include the population in southern Manitoba, but apparently the present Eastern greater sandhill population is between 35,000 and 40,000 (Table 3).

THE MISSISSIPPI SANDHILL CRANE

The Mississippi sandhill crane (*G. c. pulla*) is currently found only in Jackson County, Mississippi. It was 1st described by Aldrich (1972); this is 1 of the larger sandhill cranes. It is a much darker gray normally than either the greater or Florida subspecies, which it resembles. It is larger than the Cuban and lesser sandhill cranes. The type specimen is an adult female (United States National Museum 564841). It was raised in captivity from an egg taken 7 May 1969 near Fontainebleau, Jackson County, Mississippi.

This crane nests in several wooded swamps and at times on low dry ground that is easily flooded. McIl-

henny (1938) discovered the nesting range and noted how the birds nested in these swamps. The 9 nests that I have observed were all situated very close to trees; these surrounded 8 of the nests. Five of these nests were in shallow water; 4 were on dry land and would be flooded by even a weak rain.

Valentine and Noble (1970) reported there were 2 localities (the same was evident in 1940) used as nesting habitat. The Ocean Springs region consisted of about 3,368 ha, while the 1 near Fontainebleau was about 3,887 ha. Later Valentine and Noble found a smaller nesting region to the north and 1 to the south. These territories averaged about 185 ha in size, but the birds fed on nearby highlands in both open and pine-grown regions. Many pines were planted in the region after 1940, and these were usurping the many open regions the cranes had previously occupied. The trees are cypress (*Taxodium distichum*), long-leaf pine (*Pinus palustris*), slash pine (*P. elliottii*), and other pines planted by silviculturists.

Valentine and Noble (1970) wrote: "Two plant communities important to the ecology of the cranes are the savannas and the swamps. The greatest extent is the savanna, commonly called 'Pine Barrens,' 'Flatwoods,' 'Pitcher-plant Land,' or 'Wet Prairies.' They are grasslands with scattered longleaf pine . . . cypress, and slash pine. The wooded depressions, known locally as 'ponds' are dense to open swamps with cypress, slash and longleaf pines, and shrubs such as wax myrtle (*Myrica cerifera*), several hollies (*Ilex* spp.), swamp cyrilla (*Cyrilla racemiflora*), buckwheat tree (*Cliftonia monophylla*), sweet bay (*Magnolia virginiana*) and others."

I found the wet regions were grown heavily to grasses, pipewort (*Eriocaulon* spp.), yellow-eyed grass (*Xyris* spp.), scleria (*Scleria* spp.), and sedges. Valentine and Noble found *Scleria* was fairly abundant where the cranes nested, the common species being *Scleria baldwinii*. They found 11 nests in marshy swales and 3 on edges of swamps. They found that *Scleria*, *Carex*, *Panicum*, and *Andropogon* were used for nest materials. Ten nests averaged 114.3 (61 to 151) by 90.6 (48 to 125) cm across at the base, were 13.6 (5-23) cm tall, and were placed in an average water depth of 9.5 (0-30.5) cm. One had a runway 171.4 cm long and in several locations extra nests were built

Table 2. Composition of crane population during the summer in Southern Michigan.

Year	Adult breeders	Young reared	Nonbreeders	% of young
1952	98	39	60	19.8
1953	94	39	60	20.2
1954	86	39	63	20.7
1955	88	44	72	21.6
1956	96	36	98	15.6
1957	94	38	68	19.0
1958	100	35	81	16.2
1971	256	56	65	14.8
1972	258	53	84	13.4
1973	302	64	94	13.9
Total	1,472	443	745	16.6

within a few meters of them. Nests were built of *Scleria*, *Andropogon*, and *Carex*.

The average measurements of 17 eggs were 96.2 ± 4.5 (89 to 102.3) by 58.7 (55.1 to 62.7) ± 1.83 SD mm. They were more drab in color than northern sandhill crane eggs, more like those of the Florida race. The average weight of 6 eggs was 147.9 g (121.1 at hatching time; 162.2 when fresh). Among 36 completed sets of eggs, the mean was 1.83 eggs per clutch (7 of 1; 28 of 2; 1 of 3). Normally eggs are laid in late March or early April and both parents assume incubation duties. The average hatching date of 27 eggs in 17 nests (McIlhenny 1938; Walkinshaw 1949, 1960b, 1973b; Valentine and Noble 1970, 1976) was 16 May (20 April-19 June). Two downy chicks at hatching weighed 105.0 g (at 0600 hrs), 103 g (at 1400 hrs), and 93.4 g before they had been feed at 1400 hrs. Wing measurements were 34 and 31 mm for these birds, and both birds had exposed culmens 22 mm in length.

Habitat of the Mississippi crane was first lumbered during the 1870's. During 1915-1920 the pine was lumbered off. During the 1940's there were many savannas

Table 3. Population estimates of greater sandhill cranes.

Location	No. of cranes
British Columbia and Washington	?
Oregon and California (Littlefield and Thompson 1979)	3,200
Nevada (Drewien et al. 1976)	1,000
Idaho, Wyoming, Montana (Drewien 1973, Drewien and Bizeau 1974)	15,000
Colorado (Bieniasz 1979)	250
North Dakota (D. Johnson 1976)	2
Minnesota (J. Johnson 1976, Grewe 1977)	333
Wisconsin (Gluesing 1974, Howard 1977, Bennett 1978)	1,000
Ontario, Algoma District (Tebbel and Ankney 1979)	200
Michigan, Upper Peninsula (Taylor 1976, 1977)	2,060
Michigan, Lower Peninsula (Walkinshaw and Hoffman 1974)	500
Indiana (Goold 1977) ^a	+11,000
Total	34,545

^aBased on peak numbers counted at Jasper Pulaski WMA minus the numbers already reported earlier in the table for other components of the eastern population, e.g., Michigan, Minnesota, Ontario, and Wisconsin.

and open marshes, but shortly thereafter a paper company bought the land and planted it to pines. This change, along with suburban developments encroaching into the region, were gradually eliminating necessary isolation and marshes for crane use.

Valentine (1979) wrote: "The Mississippi Sandhill Crane . . . population . . . remains low (40-50), but stable. A total of 20 nesting territories have been located since 1965, but at least 9 appear to be deserted permanently. The Mississippi Sandhill Crane National Wildlife Refuge, established in 1974, now totals 3,490 ha, or about half the proposed refuge of 6,542 ha. Personnel from the Young Adult Conservation Corps (YACC) camp, begun in 1978, are being used for habitat management, particularly for clearing pine and brush from nesting and feeding habitats. The Bicentennial Land Heritage Program will provide funds for water management, refuge headquarters, water control structures, and winter crop units. The final Federal rulemaking delineated 10,522 ha as critical habitat." Thus it appears that this subspecies is protected for some time. Between 40 and 50 birds have been in Jackson County since McIlhenny found the region in 1938.

THE FLORIDA SANDHILL CRANE

The Florida sandhill crane (*Grus canadensis pratensis*) resides in southern Georgia and Peninsular Florida. This bird is about the size of the greater subspecies. The 2 races cannot be distinguished from each other in the field except by behavior. The Florida sandhill crane has a dark mouse-gray occiput. The wing and exposed culmen of *G. c. pratensis* average slightly shorter and the tarsus slightly longer than in *G. c. tabida*. The type specimen is from Payne's Prairie, Alachua County, Florida (Brodkorb 1955).

The Florida sandhill crane is a resident of the prairies of Florida and those in the Okefenokee Na-



Fig. 5. Florida sandhill crane in Osceola County, Florida.

tional Wildlife Refuge of southern Georgia. Most of the Florida prairies now are cattle pastures on ranches of many thousands of hectares. Thus, they are restricted to trespass, and this has aided the Florida subspecies and the greater sandhills that winter there. Through these prairies there are small wooded regions called "Hammocks" and larger more heavily wooded regions. The most characteristic trees are the cabbage palm (*Sabal palmetto*), slash pine, longleaf pine, live oak (*Quercus virginiana*), water oak (*Q. nigra*), and wetland trees such as magnolia (*Magnolia grandiflora*; *M. virginiana*) and cypress (*Taxodium distichum*). Extensive regions of prairie are often occupied by saw palmettos (*Serenoa repens*).

Scattered haphazardly across the prairies are small ponds generally grown to emergent vegetation, pickerelweed (*Pontedaria lanceolata*), bog-button (*Lachnocaulon anceps*), pipewort (*Eriocaulon decangulare*), vare goldies (*Xyris* sp.), rushes (*Juncus effusus*), arrowleaf (*Sagittaria graminea*, *S. lancifolia*; *S. latifolia*), maiden-cane (*Panicum hemitomum*), large patches of saw grass (*Cladium jamaicense*), sometimes smaller patches of cattail (*Typha domingensis*), and jointed spikerush (*Eleocharis equisetoides*). Some ponds are partly surrounded with wax myrtle and covered with St. John's wort (*Hypericum fasciculatum*).

I have seen 8 nests in the Okefenokee, 4 in Payne's Prairie, and 115 in the Kissimmee Prairie regions. All were quite similar, originally placed in a pond area grown thickly to emergent vegetation (except 1) and in shallow water (normally less than 1 m deep). Most of these ponds were surrounded by prairie and most were away from human intrusion. One nest found on the Archbold Biological Station was built on dry land; another in Highlands County was built out in the open in a newly flooded region. The mean pond size was 3.9 ha, with extremes of 0.2 to 18.2 ha. The mean distance from the nest to shore was 55.9 m (ranging between 7.6 and 182.9). The mean water depth beside 113 nests was 28.8 cm (0-74 cm), but often water disappeared completely during dry years.

The average measurements of 109 nests were 118.5 (36 to 216) by 101.8 (36 to 216) cm at water level and the average height above water level was 11.6 (7.6 to 25) cm. Nests (113) were built of the most available materials within the following vegetation: pickerelweed (63.7%), maiden-cane (20.3%), pickerelweed and maiden-cane (5.3%), *Juncus effusus* (1.8%), *Andropogon* sp. (1.8%), pickerelweed and *Sagittaria* (1.8%), *Eleocharis equisetoides* (0.9%), *Hypericum fasciculatum* (0.9%), *Panicum woodwardii* (0.9%), water hyacinth (9.9%), *Scirpus validus* (0.9%), and flotsam (0.9%).

Florida sandhill cranes lay their eggs mainly during January or February, when water conditions are optimum. For example, during 1977 and 1979 many eggs were laid in late January during the coldest weather but there had been substantial rain during December and early January. Conditions were very dry during 1974, 1975, and 1976 and many pairs remained on their territories, often built their nests, but never laid eggs. In contrast, during 1977 and 1979 cranes were nesting everywhere.

First eggs were laid (estimated from the time of hatching) as early as 23 January 1970, 20 February 1971, 4 February 1972, 5 February 1973, 18 February 1974, 14 January 1975, 7 February 1976, 22 January 1977, and 7 January 1979. The mean measurements of 148 eggs were 93.6 ± 4.6 SD (80.9 to 107.6) by 59.5 ± 2.5 SD (53.7 to 67.0) mm. The mean weight of 52 eggs was 183.4 ± 19.1 g (223.6 when fresh to 138.7 at hatch-

Table 4. Sizes of Florida sandhill crane chicks at various ages.

Age of chick	Weight (g)	Length (mm)					
		Wing from bend	Tarsus	Exposed culmen	Bare tibia	Middle toe with claw	
Birth day		33.5	39.0	23.5	21.6	28.4	
1 day	96.6	35.0	44.0	21.0	20.0		
		33.0	48.0	25.0			
		120.3	29.0	39.0	23.0		30.0
				39.0	22.5		34.6
			37.2	39.0	24.0	23.5	33.3
2 days	133.2	34.0	49.0	24.5			
		105.2	30.0	54.0	26.0		
		102.2	36.0	47.6	23.3		38.6
		110.0	35.4	44.5	22.0		35.3
			35.0	44.0	22.0	21.0	
3 days	191.6	39.0	49.0	25.0		41.0	
		36.0	50.0	26.0			
1 month		88.0	110.0	56.0			

ing). The average clutch size was 1.93 (8 of 1; 103 of 2; 1 of 3) for 112 clutches. At 1 nest the last egg laid hatched 29 days after it was laid. In another nest the last egg hatched 30 days after the nest was found. At 107 nests in which 203 eggs were laid and 156 hatched (76.8%), 85 nests had young hatch and leave (74.4%).

At hatching, chicks remain under their parent for about 24 hours then begin searching for food. Sometimes they return to the nest for a few nights and normally roost in shallow water at night just as adult cranes do. They are a lighter tawny color than chicks of greater sandhills. Table 4 is a record of weights and measurements of chicks in the field.

Parents normally lead their chicks to nearby pastures, where they are visible even from nearby highways. There they spend their days until the chicks fledge. They still roam in family groups until December when the parents again retreat to their nesting marshes. Normally the pair uses about 518 ha (2 square miles) for their daily requirements. Only 1 pair has ever been found nesting in a single pond, but pairs have been found nesting 800 m from each other and often the same pasture may be used for feeding by more than 1 pair. Their food consists of bulbs and roots (*Cyperus* sp. in Florida, *Lachnanthes tinctoria* in Georgia), roots of *Sagittaria*, some seeds, earthworms, grasshoppers, crickets, and frogs.

The Florida sandhill cranes and wintering greater sandhill cranes have recently received much better protection in Florida. Large prairie cattle ranches are now fenced and posted so that hunting is kept to a minimum. Cranes have even become quite tame in many regions and at times may be seen roaming through ranch yards, down lanes, even across highways. In the past they would nearly always fly when a car stopped near them; sometimes now they will not even look up.

Lovett Williams, Jr. (pers. comm.) considered the Florida population around 5,000 birds. This is probably reduced considerably during drought and could go as low as 4,200. But when good rains come and conditions are right, such as during the spring of 1979, the population should definitely increase.

The future looks good in 1 respect; there are several large refuges where the birds live and nest (Okefenokee National Wildlife Refuge in southern Georgia and in Florida, Payne's Prairie, Alachua County; Three-lakes Wildlife Area, Osceola County; Avon Park Wildlife Management Area, Polk and Highlands Counties; Fish-eating Creek Wildlife Management Area, Glades County; and Loxahatchee National Wildlife Refuge, Palm Beach County). Yet many of the old breeding areas have been lost to continued drainage and agriculture and many hectares of usable habitat are now going into housing developments. The increased human populations of southern Florida may definitely affect the species adversely.

THE CUBAN SANDHILL CRANE

The Cuban sandhill crane (*G. c. nesiototes*) is a resident of western Cuba and the Isle of Pines. It is similar to other sandhill cranes in appearance but smaller than the Florida subspecies. Gundlach (1875: 296) reported the total length for the male as 1,088 mm and the wingspread 1,970 mm; for the female a total length of 1,070 mm and wingspread 1,885 mm. The type specimen is an adult male taken 8 May 1904 at La Vega, Isle of Pines (Bangs and Zappey 1905:193). Measurements of the type specimen are wing chord, 490 mm; exposed culmen, 117 mm; tarsus, 217 mm; and bare tibia, 103 mm. The exposed culmen is longer than in *G. c. canadensis* but shorter than in *G. c. tabida* and *G. c. pratensis*. The tarsus is much shorter in *G. c. nesiototes* than in *G. c. tabida* and *G. c. pratensis* but somewhat similar in measurement to *G. c. rowani*.

I described their habitat and nests (1953b, 1973): "Because they live in dry isolated regions, most of these cranes may never visit a marsh, getting their drinking water from small streams, springs, and rain-pools. They roost at night and feed by day on dry land. Most of their territories are sparingly grown to shrubs and trees, often somewhat park-like, often rather flat but at times rocky and mountainous One nest was built on top of a small mountain, on a flat rock amongst large boulders, and shaded by tropical pines. All nests were built of needles of this pine, in one case these radiated spirally from the center as though the birds had turned around and around while setting. Others reported these mountain nests also. Still others found nests in flat regions, one man finding a nest in Sabana Grande, an immense open prairie, during the rainy season. It was built in a pool of water. Since mammalian predators, including dogs, were absent or scarce, the birds were bothered little except by an occasional human being Besides a growth of live grass, most regions had dry dead grasses at the nesting sites. Live vegetation nearby included scattered tropical pines (*Pinus tropicalis*), an occasional *Pinus caribaea*, palmettos (*Acoelorrhaphe wrightii*), and scattered bushes including *Hypericum stypheloides*, rompe ropa (*Tabebuia lepidophylla*), *Byrsonima verbascifolia*, *Ouratea elliptica*, *Kalmiella aggregata*, with here and there a few bottle palms (*Colpothrinax wrightii*)."

"The mountain nest measured 96 by 134 cm across and had a runway 9 cm wide, 56 cm long, extending out between the rocks. The pine needles were about 8 cm deep, and the nest, like the others, was slightly depressed in the center. The nest at Siguanea was more poorly constructed of a few needles, with eggs resting mostly in the sand. But the third nest was again a thick pile of dead needles. The three nests averaged 98 by 67 cm in width and about 4 cm thick and all were nearly circular in shape."

Peter Smellie found 2 nests in 1951 in bottle palm flats along grass-bordered arroyos but on dry ground. The 2 lowland nests I found were in dry sandy situations. The ovate-shaped eggs are very similar to those of the Florida sandhill crane but smaller and possibly a lighter drab color and have fewer spots. The measurements of 7 eggs were 87.9 (82.6 to 95) \pm 4.8 SD by 57.1 \pm 2.9 SD (53 to 60) mm, and 4 eggs averaged 123.7 \pm 26.9 SD (97.0 to 158.2). All 3 clutches consisted of 2 eggs, but Gundlach (1875) recorded an occasional 1-egg clutch. Both parents incubated eggs, and chicks have been found during late April and early May. In 1 nest, eggs hatched in mid-July.

The colts are very much like other sandhill crane chicks in color and measurements. Probably the greatest concentration of Cuban sandhill cranes has been near Los Indios, Isle of Pines. I found 8 pairs there in 1951 within 3,108 ha. The closest pairs were about 800 m apart. In 1951 they were so widely scattered that there were no territorial problems. Many of the local people then estimated that there were 100 cranes on the Isle of Pines, and the Cuban population was considered much lower by Dr. Abelardo Moreno, who in a recent letter reported the cranes were beginning to increase in numbers or were at least stable in numbers.

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THE GREATER SANDHILL CRANE

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PAST DISTRIBUTION

Although numbers are increasing at the present time the greater sandhill crane (*Grus canadensis tabida*) has disappeared from much of its former range. Coues (1883) reported that in 1792, Jeremy Belknap listed the sandhill crane as a New Hampshire bird species, and Samuel Williams reported that it was 1 of the most common "waterfowl" in Vermont. Stone (1937) stated that in 1748-49 cranes headed north over Cape May, New Jersey and that in 1670 cranes came in numbers. Since then cranes have become rare in New England and the Atlantic Coast States. Much of their former breeding range was destroyed as settlement progressed westward. Drainage of marshes, cultivation, and human disturbance resulted in this destruction, especially in the Prairie States.

Dawson (1903) reported that greater sandhills were found in great numbers in northern Ohio, especially in Huron and adjoining counties. The last nesting record for the state was in 1926. A member of the pair was shot during that year and each spring an unmated bird returned to the marsh until 1931 (Hicks 1935). Walkinshaw (1949) lists the last nesting record for Indiana as 1929, and Ridgway (1895) reported that they formerly bred in large numbers in Illinois, but by 1876 only a few still nested in 1 or 2 large marshes in the central portion of the state. Since then they have disappeared from Illinois.

In Iowa the last record was in 1905 (Anderson 1907) and in Nebraska 1904 (Cooke 1914). Visher (1910) reported that 1 pair nested in Sanborn County, South Dakota but did not list the date. One pair of sandhill cranes seen on Upper Souris National Wildlife Refuge, North Dakota, in 1941 was believed to have nested (Henry 1941).

West of the 100th meridian the nesting range of cranes also diminished but not to the extent seen in the Prairie and Lake States. Bailey and Niedrach (1965) reported that cranes formerly nested in Colorado Mountain parks up to 2,895 m elevation, but that few breeding pairs remain. In Arizona a few sandhills nested at Mormon Lake where a settler collected a set of eggs in 1886 (Mearns 1890). Until recently they nested at Fish Springs National Wildlife Refuge (NWR), Utah but no longer do so. At present efforts are underway to reestablish cranes at Fish Springs.

Greater sandhill crane nesting habitat at 1 time was probably almost continuous from the Lake States westward to California, Oregon, and Arizona, but at the present time they are divided into 4 separate populations.

PRESENT DISTRIBUTION

The 4 populations are the Eastern, Rocky Mountain, Colorado River Valley, and Central Valley.

Eastern Population

The Eastern Population nests in Wisconsin, Michigan, Minnesota, southeast Manitoba, and southwest Ontario. Largest nesting concentrations occur in the Lower Peninsula of Michigan, primarily Jackson, Washtenaw, Calhoun, Kalamazoo, Livingston, and Ingham

counties, and the Upper Peninsula in Schoolcraft, Luce, Alger, Chippewa, Mackinac, and Marquette Counties. Concentrations occur in central Wisconsin, principally in Wood, Portage, and surrounding counties (Walkinshaw 1960).

Major premigratory staging areas are in northwest Minnesota (Johnson and Stewart 1973), and Jasper Pulaski Game Preserve, Indiana. Upon departure from these staging areas the birds migrate southeast through northern Illinois, Indiana, western Ohio, central Kentucky, eastern Tennessee, and central Georgia (Walkinshaw 1960). In winter they occur from southern Georgia (Okefenokee NWR) southward into central Florida. The spring migration route is identical to that used in the fall.

Rocky Mountain Population

These nest in northwest Colorado (Routt County), eastern Idaho (primarily in Caribou, Bear, Bonneville, and Fremont Counties), western Wyoming east to the Sweetwater River in Fremont County (Drewien 1973), northeast Utah (Rich and Cache Counties), and southwestern Montana (including Beaverhead and Madison Counties).

Before their fall migration the birds congregate in western Wyoming and eastern Idaho. They migrate southeast over northeastern Utah and western Colorado. In southern Colorado most of the birds rest on Monte Vista NWR, Rio Grande County, before continuing south along the Rio Grande River to the vicinity of Bosque del Apache NWR, Socorro County, New Mexico. Many continue southward to winter near Columbus, Luna County, New Mexico; Willcox, Cochise County, Arizona; and scattered localities in Chihuahua, Mexico. In the spring the same migration route is followed.

Colorado River Valley Population

The population nests primarily in northeast Nevada (Elko and White Pine Counties) and probably central Idaho (Camas, Blaine, and Custer Counties). At present (1974) it has not been determined if the central Idaho birds are members of this population; however, recent color-marking should clarify this. In the fall they migrate south over Pahrangat Valley, Lincoln County, Nevada and continue south to their wintering areas near Parker in Yuma County, Arizona and near Brawley in Imperial County, California. The spring migration route is identical to the route in fall.

Central Valley Population

The population nests in southeast Oregon (Malheur, Harney, Lake, and Grant Counties); southcentral Oregon (Klamath and Deschutes Counties); and northeast California (Siskiyou, Modoc, Shasta, and Lassen Counties). The greatest concentrations nest at Malheur NWR and Harney Valley in Harney County; and Warner Valley, Chewaucan Valley, and Sycan Marsh in Lake County, Oregon. In California concentrations nest in Surprise Valley and in the vicinity of Alturas, Modoc County; and in Big Valley, Shasta County.

The population stages in the fall on Malheur NWR before its departure. When leaving Malheur they fly southwest to Surprise Valley. There they move south

along the Warner Mountains. East of Alturas they head west-southwest and continue to the west end of Fall River Valley, Shasta County. From Fall River Valley they fly southwest to the vicinity of Lassen National Park, Lassen County, where they turn southward and enter the Central Valley of California near Chico, Butte County. In spring they use the same migration route as in fall.

In addition to the group of birds described above a few hundred nest in southern British Columbia. These birds apparently winter in the Central Valley; therefore, they are included as a portion of this population. They migrate south from British Columbia through western Washington to Sauvie Island north of Portland. From there they continue south through western Oregon into California.

HABITAT

Summer Habitat

Greater sandhill crane nesting habitat consists of marshy situations, usually a flooded meadow for feeding with scattered emergent vegetation, used for nesting. Nesting habitat in Michigan was described by Walkinshaw (1949). In Northern Michigan, around Seney NWR, the marshes are covered with coarse and fine sedges with a few scattered stands of reeds. Through the marshes extend many sand ridges chiefly overgrown with jack pine (*Pinus banksiana*). In certain areas spruce-cedar surround the marshes. Scattered throughout the marshes are a few willows (*Salix* spp.), alders (*Alnus* spp.), and in drier situations large stands of even-growth aspens (*Populus* spp.). In other northern Michigan nesting areas leatherleaf (*Chamaedaphne calyculata*)-sphagnum bogs occur. These bogs are surrounded by black spruce (*Picea mariana*), arborvitae (*Thuja plicata*), jack pine, red pine (*Pinus resinosa*), and white pine (*P. monticola*).

In the lower peninsula of Michigan the marshes resemble those at Seney, but without jack pine. Instead the ridges are covered with white oak (*Quercus alba*), red oak (*Q. borealis*), black oak (*Q. velutina*), and aspen along with other deciduous trees. In central Wisconsin, Hammerstrom (1938) described crane habitat as tamarack (*Larix laricina*)-spruce swamps and leatherleaf-Labrador tea bogs. Drewien (1973) described the nesting habitat for the Rocky Mountain Population as 8 to 40 ha territories in wet meadows and marshy areas along streams and rivers.

Unlike other nesting territories many of the cranes that nest around Grays Lake NWR, Caribou County, Idaho are in areas with little emergent vegetation. In this

Table 1. Populations and numbers of greater sandhill cranes, 1973.

Population	Estimated number
Eastern	6,000
Rocky Mountain	10,000-15,000
Colorado River Valley	900
Central Valley	
Oregon-California	3,200
British Columbia	300
Total	20,400-25,400

region they nest in open meadows with little concealment. Vegetation surrounding the meadows includes sagebrush, aspen, Douglas fir (*Pseudotsuga taxifolia*), and various other conifers.

The Colorado River Valley Population's nesting habitat consists of a combination of emergents and open meadows in the southern portion and primarily open meadows in the north. In northeastern Nevada, at Ruby Lakes NWR, Elko County, surrounding hills are covered with sagebrush with a few aspen and juniper. In other regions the meadows are surrounded by Douglas fir and other conifers.

The Central Valley Population nests in open meadows with scattered stands of hard-stemmed bulrush (*Scirpus acutus*), cattails (*Typhus* spp.), and broad-fruited burreed. Much of the nesting area is in the Great Basin where the surrounding vegetation consists of sagebrush and scattered junipers. Nesting habitat outside the basin is surrounded by sagebrush, lodgepole pine (*Pinus contorta*), ponderosa pine (*P. ponderosa*), and Douglas fir.

Winter Habitat

Wintering regions are usually associated with agricultural developments, especially those in the West. In Florida, Walkinshaw (1973) reported that cranes feed on the prairies and move to some shallow pond or marsh for the night. The portion of the Rocky Mountain Population that winters along Rio Grande River in New Mexico feeds in milo, wheat, cotton, and barley fields. Milo fields are important feeding areas around Columbus, New Mexico; Willcox, Arizona; and in Mexico.

The Colorado River Valley Population utilizes harvested milo fields in the fall but later switches their diet to newly planted barley. Near Parker, Arizona they roost in shallow sandbars in the Colorado River. Further south near Brawley, California they feed extensively in irrigated pastureland, milo, and barley fields and roost in shallow ponds at a private gun club.

In California the Central Valley population feeds in irrigated pastureland, milo, wheat, barley, rice, and corn fields as well as saltgrass flats. Roosting sites are in shallow ponds and lakes on both private and public lands.

POPULATION MAGNITUDE

During the past 3 decades greater sandhill crane numbers have increased substantially, especially the Rocky Mountain and Eastern Populations. Walkinshaw (1949) estimated there were 1,339 to 1,836 greater in the United States in 1944. At present (1974) there are an estimated 20,400 to 25,400 (Table 1). A large percentage of this total occurs in the Rocky Mountain Population which has been increasing at a phenomenal rate. Drewien (1973) estimated the population numbered around 10,000. Other estimates have been as high as 15,000. The Eastern Population is presently estimated at 6,000. Walkinshaw (1949) estimated 162 to 260 pairs were present in the Lake states area in 1944. The Colorado River Valley Population presently consists of around 900 individuals and I do not know if this population has increased, decreased, or remained stable.

The segment of the Central Valley Population that nests in southeast and southcentral Oregon and northeast California has not increased substantially during

the past decade. However, there are several pairs that have appeared in new areas recently. Pairs have been noted near La Grande, Union County; Hart Mountain, Lake County; and Drewsey and Steen's Mountain, Harney County, Oregon occupying territories where they had not been previously seen. At present there are an estimated 3,200 individuals in this portion of the population.

For several years a few pairs nested in the vicinity of Vancouver, British Columbia but no accurate estimates were available. The population these birds belonged to was unknown. In October 1973, 260 greater sandhill cranes were seen on Sauvie Island along with several hundred lesser sandhill cranes. It is now assumed that southern British Columbia birds belong to the Central Valley Population, migrating south to Sauvie Island and on southward into California. An extensive survey of southern British Columbia is needed to determine the nesting distribution and density of cranes in that region. This portion of the population has probably increased recently.

PAST, PRESENT, AND FUTURE FIELD STUDIES

Eastern Population

Lawrence Walkinshaw has worked for many years on the Eastern Population, primarily in the Upper and Lower Peninsulas of Michigan. In recent years he has expanded his research to their wintering areas in Florida. Ernest Gluesing has recently completed a study of this population in Wisconsin, and Lovett E. Williams, Jr. has worked for several years on the population in Florida. Additional work needs to be conducted in southeast Manitoba, southwest Ontario, and Minnesota to determine what percentage of the population utilizes these areas.

Rocky Mountain Population

Rod Drewien has worked on this population on wintering and nesting areas since 1969. William Mullins also has collected data from this population.

Colorado River Valley Population

Mullins, Drewien, and Carroll Littlefield have worked to some extent on the population. Mullins has concentrated on the nesting grounds and Littlefield the wintering area.

Central Valley Population

Littlefield has conducted research on this population since 1966 on both the nesting and wintering regions. Several reports about this population will be published in the future.

LEGAL AND PRACTICAL PROTECTION OF BIRDS AND THEIR HABITATS

Greater sandhill cranes are protected under the Migratory Bird Treaty Act of 3 July 1918 between the United States and Canada which was amended in 1936 to include the United Mexican States. However, many greater are killed annually by hunters, especially in Mexico and to a lesser extent in California. The Mexican losses do not appear to be having a substantial effect on the population because most of these birds are from the Rocky Mountain Population which continues to increase at a rapid rate.

Much of the nesting habitat is on public land and this is in no immediate danger of destruction, but

approximately 70% of the nesting habitat of the Central Valley Population is on private land. In recent years native meadows have been destroyed and replaced with alfalfa. No serious losses have occurred but this situation could change in the future.

PROBLEMS FACING SPECIES SURVIVAL

At present there are no serious problems facing the subspecies' survival except in local situations. Adequate summer and winter habitats exist and at least 2 of the populations continue to increase.

A problem that developed on Malheur NWR, Oregon was the elimination of predator control on the refuge. This resulted in a rapid increase in coyotes (*Canis latrans*). In 1973 only 2 young cranes reached flight stage from the 235 breeding pairs that nested there. Hopefully, this was a unique situation and presumably will not repeat itself in the future. Black-tailed jackrabbit (*Lepus californicus*) numbers were extremely low, and the low availability of this key prey species, added to an exceptionally dry year, probably increased the nesting losses. However, this situation should be watched to see if similar losses occur in more favorable years.

SOLUTION TO PROBLEMS

If coyotes continue to cause severe damage on public lands some control is recommended. If control is prohibited and losses continue to occur it would be unfeasible to establish additional refuges where nesting sandhills are present. An example would be an addition to Grays Lake NWR, Idaho. At present most cranes nest outside the refuge where local ranchers keep coyote numbers under control. Nesting success in this area has been as high as 90% (Drewien, pers. comm.). If private land is purchased for the refuge, and coyote control eliminated, severe losses could occur in this area because most of these cranes nest in open situations with little or no emergent cover.

WHAT THE IUCN CRANE WORKING GROUP CAN DO TO HELP

The Crane Working Group of International Union for Conservation of Nature can help by informing conservation-minded organizations (e.g., Defenders of Wildlife) about problems that have occurred on localized public lands. However, more data need to be collected to further substantiate these losses. Complete predator control is not recommended but some control is definitely needed in areas where large numbers of greater sandhill cranes nest.

CAPTIVE BREEDING PROGRAMS

A captive breeding program has been in progress for several years at Patuxent Wildlife Research Center, Laurel, Maryland. Sixty-one greater sandhill cranes are now at the Center; 10 of these have been produced by eggs laid by the Patuxent captives (R. Erickson, pers. comm.). The exact numbers and locations of other captive greater are unknown at this time.

ACKNOWLEDGMENT

Thanks are expressed to Robert M. Storm for editorial comments and Joseph J. Beatty for typing assistance.

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THE MISSISSIPPI SANDHILL CRANE, 1980

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INTRODUCTION

The Mississippi sandhill crane (*Grus canadensis pulla*) was described by Aldrich (1972) from specimens raised in captivity from eggs collected in Mississippi. Other than the captive birds, the species exists only as a small nonmigratory population residing in Jackson County, Mississippi. This crane was added to the United States List of Endangered Native Fish and Wildlife (USDI 1973).

Until the early 1950's, the Mississippi crane was fairly secure. The colony was small and the habitat limited, but man's impact was not disruptive. Land use consisted of small-scale lumbering, turpentine, and open range grazing. About 1955, timber companies began silvicultural activities, ditching, plowing, and planting pine trees. Population growth along the Gulf Coast stimulated housing and commercial developments in the area. Interstate Highway 10, which transects the breeding area, has destroyed crane habitat and is attracting suburban growth. Continued growth of tourism, industry, and developments stimulated by increasing populations and increase in local highways, forest roads, and superhighways are imminent destructive agents of the crane habitats.

DISTRIBUTION: PAST AND PRESENT

Sandhill cranes nested in southern Louisiana (Cooke 1914, Figgins 1923, McIlhenny 1943, Lowery 1960) but only in small scattered colonies. Baldwin County, Alabama, had a small colony (Howell 1928) and summer records of cranes have been reported as recently as 1960 (Imhoff 1962). Winter flocks of 32 in 1971 (Hamilton 1971) and 27 in 1972 (James 1972) have been reported in Baldwin County. These cranes may be northern migrants, or possibly cranes from Jackson County, Mississippi.

The breeding range of the Mississippi sandhill crane is confined to Jackson County, from the Pascagoula River west to about the Harrison County line. The northern limit runs on an east-west line (Lat. 30°35') about 6.4 km north of Vancleave. The southern limit is Simmons Bayou and Graveline Bay, nearly to the Gulf of Mexico.

The Mississippi sandhill crane nests in fairly open wet savannas and because these did not exist more than 25.3 km from the Gulf, the total breeding range was not, with the exception of an area east of the Pascagoula River, much larger than it is today.

POPULATIONS

Historical Records

The earliest reference to the Mississippi sandhill cranes was Leopold (1929) who made a game survey of Mississippi in 1928. He briefly described the range west of the Pascagoula River, and stated that "at least fifty birds, and possibly a hundred or more, remain yearlong on the west side of Pascagoula River in west-central Jackson County, 15 miles north of Moss Point." His reference to Moss Point, which is east of the Pascagoula, is in error. He did not give any records of sightings or indicate that he saw any.

McIlhenny (1938) did not estimate the population, but cooperators counted 34 in 1 flock in April and found 11 nests with eggs in 1938. All of these nests were in the Fontainebleau area, indicating a fairly large population at that time. McIlhenny's informants knew of cranes north of Ocean Springs, but no nests were reported and only minimal information was given.

Walkinshaw (1949:140) estimated more than 25 pairs in 1940. He observed 34 in 65 hours in the field during April 1940, and found 3 nests. Turcotte (1947) estimated about 30 in 1947. He said that free-ranging hogs were the worst enemy of the crane and that some cranes were killed by hunters. Walkinshaw (1960) in March 1960 saw 9 cranes in 7 hours in the field and found 1 nest. Turcotte (1961) estimated the colony at less than 50 birds in 1961.

Recent Studies

Strong (1969) estimated the population in 1968 at between 50 and 60 birds, including 16 breeding pairs. Valentine and Noble (1970) estimated the population at between 38 and 40 cranes, based on known breeding pairs and maximum winter counts. After 6 years of study, Valentine and Noble (1970) estimated 15 breeding pairs based on known nesting territories and sightings of paired birds. This estimate held through 1975 (Valentine and Noble 1976). I estimated 12 to 15 pairs in 1978 (Valentine 1979). By then 9 territories were considered permanently abandoned, but 4 new ones had been found. The largest number of active nests in 1 season was 8 (1969), with other peaks of 7 in 1971 and 1977. Nests found per year dropped to a discouraging low of 2 in 1980 (Table 1).

Winter aerial surveys have not been satisfactory for total population estimates. My highest count was 22 in January 1977, when Sidney Woodson (FWS) and I counted 37 within the entire range (Valentine 1979). On 20 January 1977, I had counted from the ground 31 in 1 area, but only 16 in the same area on the aerial survey.

On 15 March 1978, Woodson, Schorer (FWS), and I saw only 1 crane on the aerial survey, but I believe the cranes had left their winter feeding areas and returned to the breeding grounds. No aerial surveys were made in the winter of 1978-1979, but 26 were seen from the ground in 1 area during winter. A 2-hour flight made on 14 February 1980, with Jim Kurth (FWS) over the entire crane range, revealed only 1 crane. My estimate of the total winter population is between 40 and 50 cranes.

MIGRATIONS AND MOVEMENTS

I have said that the winter population of cranes in Jackson County does not exceed the possible limits of the resident flock (Valentine and Noble 1970). Winter records of cranes in Baldwin County, Alabama, only 80 km to the east of the Mississippi crane environment, indicate a crane migration, so some northern cranes may also winter in Jackson County.

A dead crane was found several miles west of Vancleave, Jackson County, Mississippi, on 17 February 1974 (Turcotte, pers. comm.). It was first identified

Table 1. History of 20 nesting territories in Jackson County, Mississippi, 1965-1980. An X indicates when a nest was found; XX indicates 2 nests, the result of renesting.

Territory name	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total nests
Brown's 1A	X	X								X		X	XX	X	X	X	2
Brown's 1B					X		X	X									10
Brown's 2		XX	X	X	X			X		X							8
Williams 3	X											X	X	X	X	X	1
Williams 4		X			X		X			X	X	X					10
Williams 5							X		X	X							3
Williams 6							X				X	X					3
Perigall 7A		X	X			X											3
Perigall 7B					X		X										2
Perigall 8A		X	X														3
Perigall 8B								X	X								2
Simms Road 9			X	X	X												3
Simms Road 10			X														1
Fort Bayou 11				X	X						X	X	X				2
Bourne 12				X	X	X	X	X	X	X	X	X	X	X			10
Eglin Road 13				X	X	X	X	X						X			6
Vickers 15											X	X	X		X		4
St. Regis 16												X	X	X			1
Weber 19													X	X	X		2
Mallette 20														X	X		2
Total	2	6	5	5	8	4	7	5	3	5	5	5	7	5	4	2	78

as a Florida sandhill crane (*G. c. pratensis*) by Dr. John W. Aldrich but later was considered a Canadian sandhill (*G. c. rowani*).

The Mississippi crane probably does not migrate, but most birds fly to small cornfields or pastures to feed during the winter. The maximum flight distance to the feeding areas is about 16 km. The winter feeding areas are a few kilometers southeast and southwest of Vancleave.

In fall and winter the cranes mainly roost in Pascagoula Marsh, from where Paige Bayou, Bluff Creek, and Bayou Castelle flow together, to the confluence of Bluff Creek and West Pascagoula River. Some cranes fly out from the Pascagoula Marsh early in the mornings to feed in the croplands and return to the roost in the evenings. Fewer spend the day feeding in the swamps and savannas in the breeding range and fly to the roosts before dark; some apparently roost in the breeding grounds. Walkinshaw (1960) saw a total of 15 (4, 3, 2, 4, and 2) flying toward the marsh roost on the evening of 24 October 1952.

Mississippi State Conservation Officer Mallette saw 36 about 3.2 km north of Paige Bayou during the spring of 1956 (Noble, pers. comm.). Noble (Valentine and Noble 1970) counted 32 in a pasture north of Paige Bayou on 8 October 1965. The McMillans, who recorded flights over their home east of Vancleave, saw cranes flying to and from the roost and counted a maximum of 42 in 1 flock about 23 January 1967 (Strong 1969). Strong (1969) counted 25 in a cornfield 6.4 km southwest of Vancleave on 16 February 1967. During November and December 1967 the McMillans made daily observations and recorded 35 on 18 November 1967.

THE ENVIRONMENT

Area Description

The combined effect of soils, elevation, topography, and drainage patterns have created "hanging bogs," swamps, or savannas which are fairly large near the coast, but are small farther inland. The more inland wet prairies are in valleys of small rolling hills that range in elevation between 15 and 24 m above mean sea level, while the larger savannas or swamps near the coast are at elevations between 6 and 12 m above mean sea level.

The soils within the breeding range were generally wet, infertile, poorly drained, acid, and suited only for substandard grazing and timber reproduction. In the early 1950's timber companies purchased or leased the land and by plowing, draining, ditching, and planting tried to grow pine trees. The open range grazing policy in Jackson County was abolished about this time and cattle were removed from most of the land. This ended the need for burning the forests and savannas to provide green winter grass. Burning, soil conditions, and high water tables kept the savannas generally free of trees and shrubs. Without the fires some forest and swamp openings have developed cover too dense for crane nesting.

Bear Pond, a large swamp, held nests (McIlhenny 1938, Turcotte, pers. comm.) but is now too overgrown for nesting. The planting of pine trees on most of the savannas has further constricted the breeding sites. Walkinshaw (1949) observed that the Mississippi crane nested in areas with more trees than any other crane habitat that he had seen.

More recently, housing developments have extended into the breeding range from Ocean Springs on the west and Gautier on the east. The crane breeding habitat is located between the highly developed tourist centers of Gulfport and Biloxi and a growing industrial city, Pascagoula. U.S. Highway 90, a major route between the 2 areas, is becoming a strip city with numerous tourist, residential, and commercial establishments.

Interstate Highway 10 transects the breeding range. The completion of the highway will stimulate greater population and commercial growth into the area. Land prices have increased excessively. The proximity of the Pascagoula River and harbor to the Gulf of Mexico is attractive to industrial and transportation facilities, and expansion northward can be anticipated.

Feeding Habitat

The cranes in spring, summer, and fall feed on the breeding grounds in savannas, swamps, and open pine fields. During the winter they often feed in the small cornfields and pastures in the northern part of their range. There are 2 concentration areas: 1 located 14 km west of Vancleave and another 6 km southeast of Vancleave. Smaller groups (from 1 to 10) may be found in other fields and pastures. Cranes seem to feed more in grazed pastures than in croplands. Most landowners protect the cranes on their property and do not permit trespass or hunting, but the cranes are always vulnerable to sneak shooting.

Roosting Habitat

The roosting grounds may be in the breeding and feeding range, but in winter some roost in Pascagoula Marsh, near the confluence of Bluff Creek, Paige Bayou, and Bayou Castelle to West Pascagoula River, an area 2 by 9 km. The Pascagoula Marsh is an estuarine delta of the Pascagoula River and the roosting marsh is in the slightly brackish zone, with sawgrass (*Cladium jamaicense*) the main vegetative component. The creeks and bayous of the Pascagoula Marsh are used intensively for fishing and to a lesser degree by waterfowl hunters. There are no known imminent dangers, but projected environmental disruptions include possible tourist, commercial, and industrial developments in the marsh and waterways.

Breeding Habitat

There are 2 general breeding ranges that have been described (McIlhenny 1938, Valentine and Noble 1970). These range definitions are primarily for descriptive purposes but there are differences in topography, elevations, and drainage. The breeding areas are separated by Old Fort Bayou and were named after the nearby towns of Ocean Springs and Fontainebleau. Within the Ocean Springs range are 7 fairly distinct breeding areas and there are 4 in the Fontainebleau area.

Pairs and individual cranes have been seen, or inactive nests found, in areas other than those described in detail in this report and may indicate nesting sites. These places include Bear Pond, Little Bear Pond, several sites east of Brown's Trail and Ben Williams Pond, and a northern site 12.8 km west of Vancleave.

Eleven areas have recently (1965-1979) been used by cranes for nesting. One or more crane pairs have nested within these individual breeding areas. These areas have been intensively searched each year. The surface area dimensions are generalized but relate to

the better nesting habitat where nests have been found.

Brown's Trail (Fontainebleau)--The total area is about 243 ha and is within the Mississippi Sandhill Crane National Wildlife Refuge. The habitat includes a narrow swampy savanna, open pine land, and an open wet prairie with very few trees. Nests are clustered in 3 areas. Nests have been found by others, possibly referred to as the "Bayou Castelle region" (McIlhenny 1938). Three nests were found in 1966, 1 of which may have been a re-nesting effort. I believe only 1 pair is nesting on this area at present. Several hundred hectares have been planted to pine but wet conditions prevail so growth is slow. Succession of brush, bald-cypress (*Taxodium distichum*), and pine (*Pinus* spp.), is closing the cover in the swamp savanna.

Ben Williams Pond (Fontainebleau)--The area is within the refuge and includes about 324 ha. The habitat is a large swamp with a narrow strip of wet savanna edging the swamp. Natural and planted pine surround most of the swamp. McIlhenny (1938) referred to the area and Walkinshaw (1960) observed 2 nests here in 1940 and 1 in 1960. One or more nests have usually been found here each year and in 1971 we found 3. Since 1976, only 1 territory has been found.

Mary Bourne (Fontainebleau)--The area totals about 202 ha of open savanna and 162 ha of pine forest, and is part of the refuge. None of the savanna has been disturbed, and it remains a flat, wet, open prairie. The area was 1st discovered in 1968 and 1 nest has been found each year through 1977. After 1977, no nests were found on this area. No reason relating to habitat conditions can account for the absence of a nest on this territory. A crane that may have been a member of the pair was killed nearby by a plane or vehicle on 5 May 1978.

Vickers (Fontainebleau)--This savanna is adjacent to a housing development, but is shielded by a narrow pine forest. The area is within the present refuge boundary. The nesting territory is in a narrow marshy area surrounded by a drier grassland. The area is about 57 ha in size. The first nest was found in 1975 and nests were found in 1976, 1977, and 1979. None was found in 1978 or 1980.

Perigal Swamp (Ocean Springs)--The area includes a large swamp with small openings on 1 edge. Several narrow savannas surrounded by pine forests also are used by cranes for nesting. The total area is about 769 ha and is within the refuge. Walkinshaw (1960) was shown a nest here in 1940. Nests have been found in dense swampy cover and 1 nest used twice was found in a pine plantation. The environment around the swamp was open savanna in the 1950's but now is mainly a pine plantation. Interstate Highway 10 edges the area and a large highway barrow pit destroyed a nesting territory. One or 2 nests have been found here each year during the years 1966 through 1973. None was found since then.

Simms Road (Ocean Springs)--This area consists of about 364 ha of savanna, pine plantation, and natural pine forest. Two nests were found in 1967 and 1 in 1968 and 1969. None has been found since then. A timber access or fire road was built through the area in 1970. Interstate Highway 10 cuts through the south end but no nesting habitats were destroyed. The area is within the refuge.

Elgin Road (Ocean Springs)--The area is part of the refuge, and consists of about 364 ha of mixed pine

forest with fairly large openings. One nest was found each year from 1969 through 1972, but none was found again until 1977 when a nest was found. Another was found in 1978, but none since then. There has been no drastic environmental change in the nesting area that might explain the absence of a breeding pair.

St. Regis (Ocean Springs)--One nest was found in 1975, but none since. The nesting savanna is small, about 4 ha and surrounded by a narrow swamp and pine forests. Tracks, droppings, and other sign indicate that cranes still use the area. The area is within the present refuge boundary.

Weber (Ocean Springs)--This area contains the farthest north nesting site in Jackson County, and is about 9 km northwest of the closest nest. Nests were found in 2 savannas located between low hills covered by young planted pine. The savannas cover 32 ha. Nests were found in 1978 and in 1979, but none in 1980. The area is privately owned and outside the proposed refuge boundary.

Mallette (Ocean Springs)--I had previously found paired cranes in this area, but it was not until 1978 that the 1st nest was found. A nest was also found in 1979, but none in 1980. The savanna is about 16 ha in size and had been planted to pine, but growth has been slow and fairly open areas are present. The area is outside of the present and proposed refuge boundary but it is a state-owned "school section."

Fort Bayou Church (Ocean Springs)--This nesting area is typical of the scattered savannas that once were found in the northern part of the range. The total area is about 36 ha of wet prairie surrounded by pine forest and plantations. The area was discovered in 1967 and contained 1 active nest in 1968 and 1969 but none since then. The nesting site was probably abandoned by the cranes because of human activity which included the building of a road and several cabins.

PAST, PRESENT, AND FUTURE FIELD STUDIES

Based on brief field studies, Leopold (1929, unpubl.), McIlhenny (1938), Turcotte (1947, 1961, 1971), and Walkinshaw (1949, 1960) have written about the Mississippi crane. Valentine and Noble (1970, 1976) collected data on life histories from 1963 through 1975. Noble and Strong (1969, unpubl.), Mississippi Game and Fish Commission, studied nesting, populations, ranges, and movements during 1966-1968. Valentine (1978) has worked in the area (1963-1980) on various assignments relating to the impact of Interstate Highway 10 on the crane habitats, the reintroduction of sandhill cranes to Louisiana, refuge land acquisition, life history, and habitat management.

Based on field studies, the activity ranges (breeding, feeding, and roosting), the parameters of the population, the various habitats, most of the nesting territories, and the dangers to the crane and its environment are known. We can improve and expand habitats needed for nesting, feeding, and roosting. Through education and public support, law enforcement, and reduction of disturbance we can give greater protection to the cranes.

There are basic biological questions unanswered, but empirical knowledge for habitat management is available. The Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR) has been established, and studies will examine and monitor the effects of habitat management. The revised Recovery Plan (Valentine

et al. 1979) recommends a number of studies relating to populations, nesting, and productivity. Various aspects of aviculture, including behavior, physiology, nutrition, and artificial insemination, are being studied at the Patuxent Wildlife Research Center (PWRC). Methodology for captive crane releases is being developed (Konrad 1976, Nesbitt 1979), but additional knowledge is needed.

The FWS plans to release captive parent-raised young cranes on the MSCNWR in late 1980 or early 1981. A study will be designed to assess the success or failure of the release by observing crane behavior within the release pen and in the wild, and by following the movements of the cranes after release. The cranes will be equipped with radio transmitters and will be tracked by portable receivers after they leave the release pen.

CAPTIVE BREEDING PROGRAM

I proposed a Bureau of Sport Fisheries and Wildlife (Refuge Division) study to reintroduce sandhill cranes to southwestern Louisiana (Valentine 1964, unpubl.). I suggested that eggs from sandhill cranes in Florida be collected for captive propagation, but the Bureau's Committee on Rare and Endangered Species in 1964 insisted that both Mississippi and Florida crane eggs be taken because of their unknown subspecific relationship to the extirpated Louisiana crane. Eggs from Mississippi and Florida have been incubated in Lafayette, Louisiana, by John Lynch; by a propagation station at the Monte Vista National Wildlife Refuge in Colorado; and later at the PWRC, Laurel, Maryland.

Under agreements with the Mississippi Game and Fish Commission, 1 egg was taken from each 2-egg clutch for a maximum of 6 eggs per year, during the period 1965 through 1977. The largest number collected was 5 in 1970 when 8 nests were found. The egg collection was suspended while facilities at PWRC were being enlarged. Searches for nests were by foot, horseback, airplane, and helicopter. Recent search-time on foot has been 41 man-hours (1980), 40 man-hours (1979), 90 man-hours (1978), 23 man-hours (1977), 44 man-hours (1976), 68 man-hours (1975), and 111 man-hours (1974). Most of the eggs when collected were placed into a water-heated carrying case and transported by personnel via airline to the PWRC. In 1973 and 1974, the eggs were air-shipped unheated in special egg cartons. After 1974 the airline refused to ship then in that manner, so they were carried each year in an unheated but insulated case. The eggs have been incubated under silkie hens, commercial incubators, and more recently, by the parents or foster-parents.

In the early efforts of propagation, hatching success of Mississippi eggs was low and the young suffered from leg and foot debilities. In some chicks the food problems were corrected and the crane survived to adulthood, but in others the weakness eventually caused death. Recently, with improved methods, most limb and foot weaknesses have been eliminated. Low fertility and hatchability of the eggs continues to be the major problem, but by increasing the insemination (artificial) frequency, PWRC hopes to raise the fertility rate (Derrickson, pers. comm.).

As the captive cranes approach adulthood they are rendered flightless and released in a 0.8-ha enclosure where they are provided food and water. The cranes are free to choose their mates or companions, select their territory, and build a nest in the grass. When pairing is definite, the 2 cranes are moved to breeding pens in the fall. The females of breeding pairs

are inseminated artificially in spring. When the eggs are laid they are removed and incubated by machine or under cranes. Chicks that are to be released are incubated by surrogate parents in large pens away from human contact. When the young cranes become independent and approach flight stage they are brailed and put into a large grassy enclosure. Human contact is kept at a minimum so that the cranes maintain a wildness that is essential for a successful release.

As of November 1980, there were 6 breeding pairs, and 15 subadults at PWRC. Two breeding pairs were transferred to the National Zoo facilities at Front Royal, Virginia, in 1980. During the 1980 breeding season 39 eggs were laid at PWRC. Of these, 14 were fertile and 13 hatched. Eight young were reared to the subadult stage. These young plus 1 from the 1979 season will be released into the wild on the refuge. All of the cranes to be released were incubated under foster-parents and raised in semiwild conditions (Derrickson, pers. comm.).

A 2.4-ha enclosure was built in 1980 on the MSCNWR. The pen encloses about 2.0 ha of wet marshy ground and the rest is high ground that will be planted to ryegrass (*Lolium multiflorum*) and other crops. A crop patch has also been prepared outside of the enclosure to attract wild cranes to the area. Corn and other grains will be scattered inside and outside the pen in anticipation that the wild cranes will come along with the captive birds. I believe it is important that the released cranes become integrated into the wild flock during the early stages of the release, so the captive will be introduced safely into the environment and learn the ways of the wild from the local flock.

CONSERVATION

Legal Aspects

The sandhill crane is protected under the provisions of the Migratory Bird Treaty Act of 1918, as amended. The Mississippi sandhill crane was grouped with the Florida sandhill crane and listed as "rare" in the 1968 List of Rare and Endangered Fish and Wildlife of the United States. On 4 June 1973 the Mississippi sandhill crane was added to the United States List of Endangered Native Fish and Wildlife (Federal Register, v.38, No. 106).

The Endangered Species Act of 1973, P.L. 93-205, was signed by the President on 28 December 1973. The law provides for land acquisition by the Secretary of Interior under the Fish and Wildlife Act of 1956 as amended, the Fish and Wildlife Coordination Act as amended, and the Migratory Bird Coordination Act, and "such authority shall be in addition to any other land acquisition authority vested in him." Funds made available through the Land and Water Conservation Fund Act of 1965, as amended, may be used for land purchases.

The Act provides for cooperative agreements between the Secretary of Interior and the states. Among other things, an agreement makes a state eligible to receive allocations of federal funds on a cost-sharing basis for projects to benefit endangered and threatened species.

Critical Habitat

Critical habitat protection is provided by Section 7 of the Act, which charges federal agencies with the responsibility for ensuring that actions authorized, funded, or carried out by them do not jeopardize the

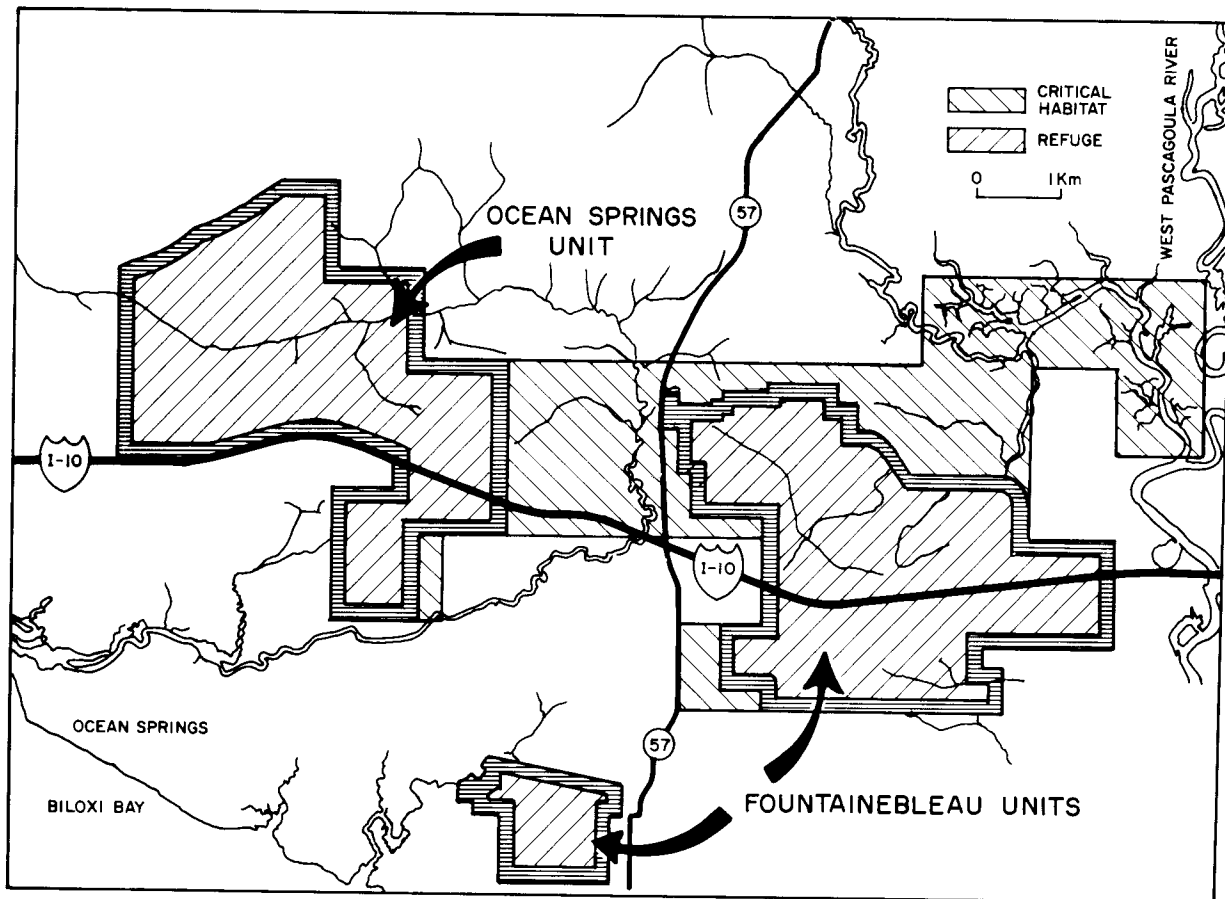


Fig. 1. Mississippi sandhill crane national wildlife refuge and critical habitat, Jackson County, Mississippi.

continued existence of Endangered or Threatened Species or destroy or adversely modify the habitats of those species. Critical habitat is the area of land, water, and airspace required for the normal needs and survival of a species. When the final critical habitat determination is published, federal agencies managing lands or administering programs within the area must examine their actions related to Section 7.

An emergency determination of critical habitat for the Mississippi crane was made on 25 June 1975, the day before the hearing of *Coleman et al. vs. the National Wildlife Federation* held in U.S. District Court. This suit enjoined the highway departments from continuing the construction of Interstate Highway I-10 under Section 7, Endangered Species Act of 1973 (Valentine and Noble 1976, Valentine 1979). The first determination of critical habitat described an area of 40,470 ha but this was reduced to 10,522 ha in the final rulemaking of 8 August 1977 (Fig. 1).

The Mississippi crane was involved in the 1st test of the Endangered Species Act to reach the U.S. Supreme Court, when the Court upheld the 5th U.S. Circuit Court of Appeals decision stopping construction of an interchange on Interstate Highway I-10 (Valentine 1979). As a result of this decision, the U.S. Department of Transportation was required to acquire about 793 ha of land along the Gautier-Vancleave Road and the land around the proposed interchange, before it could be constructed. The land is now part of the refuge, and the interchange is being constructed.

State of Mississippi

The Legislature of the State of Mississippi enacted House Bill 614, "An Act to provide for the conservation, management, enhancement and protection of non-game fish and wildlife and species threatened with extinction; to provide enforcement authority and penalties for violations of this act; and for related purposes." The Nongame and Endangered Species Act was signed by the Governor during the Regular Session of the 1974 Legislature.

Funding may be made available to the Mississippi Game and Fish Commission from the General Fund or from other sources. These funds will be separate and known as The Endangered Species Protection Fund. The Commission issued an "endangered species stamp" for additional revenue to be deposited in the Endangered Species Protection Fund. The Mississippi sandhill crane was illustrated on the 1st stamp.

Restoration Programs

The Mississippi Game and Fish Commission, now the Mississippi Department of Wildlife Conservation, has participated in crane conservation through its Game and Fish and Law Enforcement Divisions. The State Department has also cooperated since 1964 with the FWS in its crane propagation and reintroduction program.

A Recovery Team was appointed by the U.S. Fish and Wildlife Service (FWS) in 1975 and the Recovery Plan

was approved in September 1976 by the Director (Valentine 1979). The Plan was revised and approved in October 1979. The objective is to save the Mississippi crane from extinction by preserving, protecting, and enhancing the crane environment in Jackson County, increasing the population, and by reestablishing crane colonies within its former range if feasible (Recovery Plan 1979). The main goal is to provide a complete life support system within the existing range to maintain a population of 80 to 100 cranes.

The MSCNWR was established in 1974 (Fig. 1). The refuge presently includes 3 separate units totalling 6,070 ha with a goal of 6,880 ha. A systematic burning program has been established because encroachment of trees and brush has eliminated or restricted nesting habitats. Savannas will be burned to maintain openings for nesting, feeding, and roosting. Mature forests will be commercially harvested and also burned to create a park-like situation for feeding and roosting. Drainage and roadside ditches will be plugged to retard water runoff.

A Young Adult Conservation Corps (YACC) camp was established in 1978. Aside from cleaning litter from the roads and trails and other housekeeping chores, the YACC's main occupation has been hand-clearing brush and trees in potential and actual nesting habitats. To date, they have cleared 202 ha and will clear 1,447 ha in the next 5 years, if the program is continued.

Five low-level dams have been constructed by raising road elevations across drainage systems. Water control structures with drop-logs were built into the dams so that water can be held or released as conditions permit. The purpose is to maintain wetter conditions in the nesting and adjoining feeding habitats located in the savannas and swamps. About 607 ha of pine plantations were cleared by bulldozing during 1980. The main purpose was to remove the pine trees and create open grasslands, but some areas were plowed, tilled, and planted to corn (*Zea mays*) and Japanese millet (*Echinochloa crusgalli*). A portion has been planted to Bermuda grass (*Cynodon dactylon*) which may be used as a cattle pasture.

Several improved pastures were acquired as part of the refuge. One wet area will be allowed to revert to savanna, but others will be mowed and maintained as pastures for livestock. Cattle pastures appear to be more attractive to cranes than croplands. Pastures are useful habitat at all seasons, whereas croplands are only used in late winter after the crops have been harvested. Also, in this warm climate, the cranes do not seem to require foods high in carbohydrates except during the infrequent cold spells. About 2,023 ha will be burned annually to maintain open nesting and feeding savannas, and to create an open understory in the mature pine forests.

A FINAL CAVEAT

There is littler opportunity to expand the range of the Mississippi cranes. Potential nesting sites in the form of small savannas still exist in places outside of the refuge, but the inherent dangers and limitations that originally jeopardized the cranes are still operating-silviculture, natural encroachment of brush and trees, roads and highways, housing and other developments, and hunting. The survival and increase of the cranes depends primarily on 2 conditions: improvement of the habitats within the refuge and the captive propagation and release program.

The 1st priority in habitat management is the increase and expansion of nesting habitats. Progress has been made, but additional work is needed. This project requires hand labor for cutting and clearing of pine trees and brush, and also a systematic burning program. The clearing and burning of the savannas and pine forests will also improve and enlarge the feeding and roosting habitats. The refuge was fortunate to acquire several small pastures and potential crop units. After the clearing of pine plantations, several hundred hectares were prepared for pasture and crops. These winter feeding sites are needed to attract cranes away from their traditional winter feeding and roosting grounds to the refuge where they will be given greater protection.

The temptation exists to apply the "multiple-use" concept on public lands, particularly those dedicated to wildlife. The Recovery Plan warns that no management should be done to improve the range for deer or other game because this would create a demand for hunting and would also make the habitat less suitable for cranes. There are already too many deer, and poaching is a problem. The 5 dams and water control structures are to improve the water economy and enlarge the marshy edges of swamps, but should not be used to create lakes or ponds for waterfowl or other water birds.

A delicate balance must be maintained between improving the environment for cranes without enhancing it for predatory birds and mammals. Mammalian predators are scarce in the nesting habitats because of the infertile nature of the soil which does not provide a food base for rodents and rabbits. The swamps and water courses are intermittent with only a tenuous connection to permanent water sources. Under optimum conditions, small fish are present in the swamps and streams, but they die with extended droughts, causing even the water snakes and raccoons to suffer.

Nest predation has been slight when compared to that on the Malheur National Wildlife Refuge, Oregon, where predation loss by ravens, raccoons, and coyotes during 1966 through 1974 was 51% of 456 nests (Littlefield 1976). Only 3 clutches (6%) of 52 known nests were destroyed by crows in Jackson County during 1966 through 1980. Predation was precipitated by human disturbance which caused the cranes to leave the nest, thus exposing the eggs. Crows do not ordinarily feed in the crane nesting areas, but a garbage dump had been established which attracted hundreds of crows to the site. The dump has been acquired by the FWS and will be closed and covered.

There has been a progressive loss of breeding pairs in known nesting sites. In some situations there has been a definite deterioration of the habitat causing the birds to permanently abandon the territory. Some pairs may have moved to another location after conditions in the original territory became intolerable, but there are disturbing losses that have no explanation other than the death of 1 or both cranes. There is the possibility that all of the nesting territories are not being found despite our intensive searches. Some evidence exists for this, e.g., after several years' absence (up to 4 years) a nest was found in a formerly occupied territory.

Among 20 known territories, 3 have contained active nests for 10 or more years (Table 1). Brown 1B (1966-1980), Williams 4 (1968-1980), and Bourne 12 (1968-1977). Two held nests from 6 to 8 years; the rest from 1 to 4 years. Since 1977, when 7 nests were found, the annual number of nests found has dropped to

a low in 1980 when only 2 were found, all on the refuge.

I believe it essential that the captive propagation program be enlarged and accelerated. There are pairs still nesting in the wild that are not represented by progeny in captivity. In order to have the greatest mix of genetic material for future releases, eggs from these pairs should be collected and young raised to provide captive breeding stock. With sufficient breeding stock, and by using artificial insemination, captive propagation can produce more young than the wild flock. The whole enterprise depends on the successful introduction of cranes into the wild and their future as wild breeding stock.

Considerable animosity against the crane was generated during the Interstate Highway I-10 controversy because the local public was led to believe that the crane was delaying the construction of the highway and an interchange. The critical habitat determination and establishment of the refuge were also opposed because of the possible effect on economic development. Editorials, newspaper accounts, and "letters to the editor" created an atmosphere of blatant opposition to the crane. A rash of wildfires burned on private and federal forests lands during that period that might have had their origin in malice. No concrete evidence exists to prove the shooting of cranes, but sport hunting for deer, turkey, waterfowl, and other game is common within the winter feeding and roosting range of the crane, and cranes are large and attractive targets. Most landowners who have cranes on their land protect them to the extent of prohibiting trespass, but sneak shooting is always possible, particularly in small isolated fields.

Now that the highway has been constructed, the interchange is being built, and the refuge nearly completed, the conflict should abate and better public relations should follow. Eventually, the local community will accept the crane and the refuge with pride as valuable aesthetic resources and economic assets as tourist attractions.

Acknowledgments.--I am indebted in many ways to many people. To all who have contributed in any way to the preservation of a noble bird I give thanks.

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CAPTURING AND MARKING SANDHILL CRANES

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Very few sandhill cranes (*Grus canadensis*) had been captured alive until recently. The methods that have been successful are projected nets (Wheeler and Lewis 1972, Ramakka 1979) and oral drugs (Williams and Phillips 1973). A few other approaches have been tried (Wheeler and Lewis 1972) but with limited success. The "cannon" net trap is adapted from the waterfowl capture technique and equipment described by Dill and Thornsby (1950). The drug capture method was developed for wild turkeys (*Meleagris gallopavo*) and used successfully on sandhill cranes (Williams and Phillips 1973) with minor adaptations.

Marking techniques include the standard U.S. Fish and Wildlife Service metal leg bands, patagial tags adapted from the technique described for turkeys (Knowlton et al. 1964), and a few other methods that have been tested. Baiting and captive handling recommendations were worked out by trial and error in our studies in Florida.

The reader is cautioned that capturing and handling large birds, especially cranes, requires skills that cannot be communicated by the written word. No one should attempt to capture sandhill cranes without carefully studying adequate references and obtaining first-hand experience under the close supervision of an expert on the technique. Federal and state permits are required to capture cranes and special authorization is required to deal with endangered sandhill crane subspecies and populations. The U.S. Food and Drug Administration has regulations restricting the use of drugs on wildlife species that are intended for human consumption and those regulations apply to the sandhill crane where the species is legally hunted.

PREBAITING

Cranes readily eat whole shelled and cracked yellow corn when they encounter it, at any season, and can be conditioned to seek it at a given place and time by regular baiting. A bait site should be selected where cranes are feeding regularly and where no human intrusion will spoil the baiting or capturing operations by frightening the birds.

Open areas with good ground-level visibility are best for drugging. Small openings can be used with projected nets but this is rarely a factor in site selection because feeding and resting areas are normally in large open areas.

Fresh bait should be placed at an intended capture site every day in amounts that will be eaten by cranes in 1 day. This avoids waste, reduces problems caused by other animals feeding at the site, and conditions the cranes to come directly to the bait early in the day (or else face the likelihood of finding no bait when they do come). The quantity of bait used in prebaiting can be adjusted to the number of cranes using the site.

Prebaiting should proceed until a sufficient number of birds are feeding heavily and regularly within 2

hours after they leave the roost in the morning (Fig. 1). Early morning feeding is especially desirable for drugging because the greater food intake on an empty stomach speeds narcosis. Early morning trapping has several other advantages, namely: (1) cranes are more punctual at the bait site with their stomachs empty; (2) preparations for trapping can be made in predawn darkness while the cranes are roosting; and (3) when birds are captured the remainder of the day is available for banding, cleaning up the capture site, and other work.

BLINDS

Any sight-proof shelter within good viewing range of the bait site can be used for drugging operations but a blind must be within 400 m if projected nets are used because of the requirement for electric extension cords from the blind to the net. Nothing is gained by having the blind within about 50 m of the bait and it is better to place the blind about 100 m away. Small tents, wooden buildings, or portable photography and hunting blinds are suitable. Only a small peep hole is needed to view the bait site and care should be taken to preclude light and noise from inside the blind. A blind should be erected and tested at the bait site in the presence of cranes for about a week, or until the cranes become accustomed to it.

DECOYS

I have not tested crane decoys but I have noticed that after 1 crane is at the bait, others flying or standing in the vicinity quickly follow. The late Robert H. Wheeler used this behavior to good advantage in Nebraska by staking out taxidermy mounts of sandhills as decoys at bait sites for projected nets (Wheeler and Lewis 1972).

PROJECTED NETS

When "cannon" or "rocket" nets are to be used, dummy sets should be laid out at the capture site during prebaiting operations at least 1 week before capturing is anticipated. The set should include a facsimile of each component of the actual capture equipment including fake cannon barrels (or recoilless rockets), old nets gathered in a long line to resemble the real nets for firing, electric extension cords, and any other equipment that is to be used later in the capture operation. The dummy equipment should be replaced by the operational equipment 1 or 2 days before the capture attempt.

After the dummy nets are set in place, bait should be placed only in front of them so that cranes will not become accustomed to looking for bait on the wrong side of the net. Bait should be placed progressively closer to the nets each day, until it is in a narrow line toward the center of the net edge and about 2 m in front of the net (Fig. 2). Capture should be attempted as soon as the birds are within 3 m of the nets.

One or more nets may be used. Single nets should be at least 12 by 18 m; double and multiple nets can be smaller, down to about 9 by 15 m. Double and multiple net sets are placed end to end or parallel, or both, to be fired toward each other about 10 m apart

¹This is in part a contribution of the Federal Aid to Wildlife Restoration Program, Florida Pittman-Robertson Project W-41.



Fig. 1. When properly prebaited, cranes congregate on the bait site.

so that when spread they overlap about 2 m. Cannons and rockets should be angled about 35 degrees above horizontal. Three or 4 cannons or rockets are required to propel a 9- by 18-m net.

Propellant strength, size (and whether it is wet or dry), angle of firing, and many other factors complicate description of the projected netting technique. The would-be crane trapper should carefully study Dill and Thornsbury (1950), Austin (1966), Wheeler and Lewis (1972), Ramakka (1979), and all other references available on the technique. The reader will then realize that no standard method exists and that he will have to practice cannon netting to acquire the needed skill. State and federal game departments and refuges have wildlife biologists skilled in cannon netting who can demonstrate the method. Additional practice can be easily gained by test firing of the equipment until satisfactory projection angles and net spread are attained. Trapping should not be attempted until perfect firings can be made consistently because cranes will not use a trap site again after being fired upon there, successfully or unsuccessfully.

When cranes are captured in the net, the operator should leave the blind, proceed to the net, and remove

the birds as quickly as possible (Fig. 3). The number of birds escaping depends partly on how many are near enough to the edges of the net to scramble out from under it after it settles on the ground. Those should be grabbed first and twisted by hand in a bagged portion of the net to be left until they can be removed to boxes or crates.

ORAL DRUGS

Alpha-chloralose is the only drug that has been used successfully to capture sandhill cranes (Williams and Phillips 1973) although other compounds as yet untested may be as good or better. I tested tribromoethanol, a superior drug for turkeys, and found that sandhill cranes are able to detect it on the bait and will not eat enough to become narcotized.

An oral drug when used properly has a few advantages over projected nets but it is not a substitute for trapping skill. A person who knows too little about crane trapping to use nets effectively has no business using drugs either. Although mortality rates are similar for nets and drugs (under 10%), drugs have the greater potential for a serious poisoning incident and should not be used by the unskilled without expert

supervision. State and federal drug laws and wildlife regulations prohibit the use of oral drugs (or so-called tranquilizers) on wildlife except when explicitly permitted in writing.

Prebaiting and other preparations for capture using drugs are basically the same as for rocket netting. Additional information can be obtained from a description of the method to capture wild turkeys (Williams 1966). Whole yellow shelled corn, the recommended bait, is measured by volume in standard measuring cups and dampened in a small amount of water for 1 minute; the excess water is poured off and permitted to stand in the bucket for about another minute. The powdered drug is then stirred in with a large metal kitchen spoon. Much of the drug will fall off if treated bait is permitted to dry before handling at the bait site. If a long delay between mixing and use is expected, the measured corn should be soaked in water for about 15 minutes so it will not dry quickly. The treated bait should be placed on the capture site after mixing in the manner used for prebaiting.

Recommended dosage is 0.4 to 0.5 g of alpha-chloralose per dry-measured cup of whole corn. Heavier dosages produce mortality exceeding 10%; lighter dosages result in subeffective narcosis. One cup of treated bait should be used for every 4 cranes using the capture site. If in doubt, use more. Particle size of the bait influences the degree of narcosis at a given dosage mixture. For example, somewhat heavier dosages are required for cracked corn than for whole corn. Wheat and other small whole grains also require more alpha-chloralose but the exact dosage for various particle sizes remains to be determined.

Cranes captured on alpha-chloralose recover after about 12 hours to 2 days depending upon the dosage application, amount of bait eaten, size of the bird, and other factors. A few of the more lightly drugged individuals can be released the same day they are captured but most must be held overnight in a safe place. The capture site must be thoroughly cleaned of all treated bait remaining after a capture operation and a large amount of fresh bait should be put out.

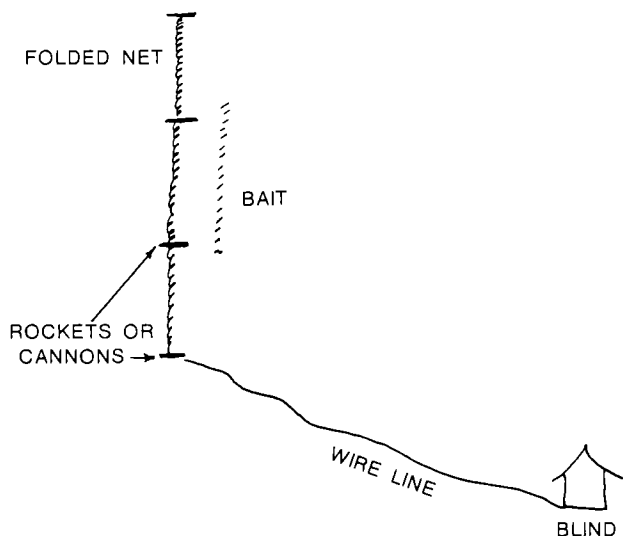


Fig. 2. Diagrammatic layout for single cannon net set. Observation blind should not be in the cannons' line of fire.

A total of 266 cranes were captured with experimental dosages of alpha-chloralose in Florida. The optimum dosage in those trials (0.50 g per cup of bait) produced no mortality and subsequent use of that dosage on about 70 additional cranes resulted in less than 2% mortality.

Cranes begin to show signs of narcosis within 20 minutes after beginning to feed and will fall down repeatedly for several minutes before reaching a state of narcosis that permits capture. After about 2 hours, we begin to pick them up with the long-handled dip nets. After that much time, those that cannot be approached closely will recover from their mild narcosis within a few hours and are probably safe in their natural habitat. Alpha-chloralose has been used only on greater (*G. c. tabida*) and Florida (*G. c. pratensis*) sandhills, to my knowledge.

MARKING

Normally, live cranes are banded with a single size 8 or 9 conventional U.S. Fish and Wildlife Service leg band. The Bird Banding Manual (U.S. Fish and Wildlife Service) should be consulted. Cranes may be banded at either of 2 positions on each leg--at the "foot" and above the joint at proximal end of tarsometatarsus (above the "knee"). If a single metal band is used, it is sometimes best to band above the knee so that the band will be visible on a standing bird and less likely to be caught in low vegetation and fences.

It is possible to use the 4 different band positions (2 on each leg) to permanently mark 13 cranes individually. In that system, the combination of bands and their positions are unique for each of the 13 birds with 1 bird carrying 4 bands, 4 carrying 3 bands, and so on.



Fig. 3. Two or 3 people should quickly remove netted cranes to holding boxes. Both legs should be grasped at the same time and care should be taken to avoid being pecked.



Fig. 4. Colored plasticized cloth markers are attached to the wing through the patagium with rivets. These markers are visible on live cranes at distances of several hundred meters.

Wheeler and Lewis (1972) and Tacha (1979) discuss the possible adverse effects of color-marking (exact types of markers not specified) and repeat reports by other writers of aberrant behavior attributed to color-markings. Some marking paraphernalia may cause problems but in our experience with patagial tags (Knowlton et al. 1964), colored plastic leg bands, and plumage dyes no adverse effects were seen in numerous Florida and greater sandhills we have marked. Florida cranes with multiple leg bands, colored plastic leg



Fig. 5. Cloth sacks can be used for weighing and temporary holding but cranes should not be left in them for long periods.

bands, and double patagial markers (all on the same birds) are known to have remained paired after marking and have reproduced and behaved normally for up to 10 years. We have used dyes only on the underside of the wings in connection with molt studies and have noticed no effect on behavior.

Patagial markers (Fig. 4) used in our early work were attached with an aluminum rivet which is no longer on the market. A plastic substitute by Wildlife Materials, Inc., Route 3, Carbondale, Illinois 62901, has been a good substitute on free-living Florida sandhill cranes. Thin plastic sheets or plasticized cloths are used for tags. Suitable material in several colors is available from Safety Flag Co. of America, P.O. Box 1005, Pawtucket, Rhode Island 02862, and probably from other sources.

To apply the tagging material, a 0.3-cm hole is punched with a sharp pointed knife through the patagium into which 1 part of the rivet is inserted from the underside of the wing. The other half of the rivet is applied from the upper side of the wing through the tagging material. The plastic rivet is fastened with pliers. The marking material may also be used on the underside of the wing to mark both sides. Special permits from the U.S. Fish and Wildlife Service are required to use any markers, in combination with the standard leg band, on birds under the authority given by federal bird banding permits (see also Reynolds 1979).

Radio transmitters weighing up to 90 g have been used successfully without adverse effect on Florida sandhill cranes that were later known to pair, nest, reproduce, defend territories, and survive through the time that the transmitter straps broke after several months. The same individuals were also wearing patagial markers, colored plastic leg bands, and some also had multiple leg bands.

Several transmitter fitting arrangements have been tried (see Crete and Toepler 1978, Toepler and Crete 1979, and Drewien and Bizeau 1981 in this publication). The simple underwing loops of surgical tubing used on turkeys (Williams et al. 1969) were unsatisfactory because the long humerus and upright posture of the cranes permits the radio package to slip loosely down the back, but another arrangement of surgical tubing worked well.

HANDLING, HOLDING, AND RELEASING

Unless there are compelling reasons to do otherwise, cranes should be released at the capture site as soon as possible after being captured. Cranes should be removed from nets and, when oral drugs are used, picked up in a state of narcosis and placed in individual crates, strong pasteboard boxes, or wire pens or cages well removed from human and animal activities. Cranes should never be placed in large wire cages, closed rooms, barns, or other roomy places if they are likely to be startled. Close confinement in boxes and crates can cause paralysis of the legs. Confinement in cloth sacks with legs tied and heads poked through small holes is not recommended except for short periods (less than 2 hours; Fig. 5) and only under emergency conditions because of the likelihood of injury to the toes (especially the hind toe), leg paralysis, and pecking injuries to other cranes and the handlers. Sandhill cranes are strong, determined, and fragile; consequently, handling injuries are common. These injuries can be avoided only by proper advance preparations, great care, and experience in handling cranes.

Before placement in boxes and after removal from captivity cranes can be safely hand-grasped simultaneously by both upper leg joints or both humeri, or bagged in a large long-handled dip net. A crane should never be held by 1 wing or 1 leg. Except in heavily narcotized cranes the bill is a definite hazard to the captor and 2 persons are needed to properly handle a bird. One person should hold the bill, head, and 1 wing, and the other hold the legs and 1 wing, or in some other way be certain that wings, legs, and head are under control. The claws are very sharp and are used as the crane's major defensive weapon.

After banding and other processing (see Tacha and Lewis 1979 for method of sex determination), cranes should be taken to the release site and turned loose as gently as possible. The immediate release area should be cleared of unnecessary people, vehicles, and be away from fences. Care should be taken to detect subtle injuries when the cranes are released and any seriously injured cranes should be checked in the field before nightfall to avoid the possibility of predation by nocturnal predators.

If oral drugs have been used and more trapping is anticipated, the same bait site can be prepared immediately for capturing again about 1 week later. If projected nets were used, another site about 1 km away should be prebaited because the first trap site probably will not be visited again soon by cranes. It is possible, however, that a portion of the cranes that had customarily used a given prebait site were not present to witness the net projection and may continue to use the same site after a few days. This can be determined by continuing to bait the place and observe whether cranes use it or not.

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Common Crane



Photo by L. Walkinshaw.

COMMON CRANES IN EUROPE

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It is not easy to discuss the common crane (*Grus grus*) in this specialized surrounding of the red-crowned crane (*G. japonensis*). Nevertheless, in my opinion it is important to consider this relatively abundant crane because we can learn a lot from them. It is important to examine the common crane to determine if aspects of their conservation can be applied universally to other species. I will discuss some experiences from my observations in several areas where the common crane is found. In the Netherlands the crane does not nest and they migrate through only the eastern parts during a few days in spring and autumn. Therefore, to me, cranes mean traveling and searching for them, swearing in the fog, grumbling in the rain, and being pleased in the sunshine. These are also the real meanings of cranes; they are symbols of life, whim, and mood.

There are 4 habitats where common cranes are found --breeding areas, wintering areas, resting areas between the former 2, and the migration pathways between these 3 habitats. Common cranes are migrants, so it is important to study their movements to ensure better protection. The populations of common cranes are not so large that they can sustain heavy regular losses or regular disturbances. The common crane is concentrating in Europe in ever larger groups, indicating not population increases but fewer suitable areas for the cranes. The restricted habitat and distribution makes their position more critical each year.

BREEDING AREAS

Most common crane breeding areas are in northern Europe and Siberia. In northern Europe the nesting areas are in isolated marshes and woods and for this reason they are not as threatened as other nest habitat. These large areas change completely only when they are to be used for hydroelectric lakes and similar large projects. Even tourists are not a threat, because there are too many mosquitos or the areas are very large. As a nesting bird, the crane disappeared from England and Holland in the 16th and 17th centuries, and from Hungary, Yugoslavia, and Romania in the 20th century.

In the Federal Republic of Germany (FRG) about 20 pairs still nest, but almost every nest has to be protected against photographers, egg collectors, bird lovers, and sensation seekers. Several nesting places have disappeared due to drainage, afforestation, real-otment, and other factors. Nature conservation organizations try to ensure the future of the FRG breeding cranes through better protection and management of the areas, and by trying to create new areas where cranes can breed. These new areas are mostly existing marshes or moors where ornithologists believe that cranes could nest. Elsewhere in eastern Europe many nest sites are threatened by the developments mentioned above, and recreational activities threaten small breeding areas.

I believe the nesting areas in Turkey and their surroundings are very important. Turkey probably is the only practical source of common cranes for reintroduction into several neighboring countries. I do not know how many cranes nest in Turkey, but it is several hundred. In September you can find many cranes at the Tuz Golu, near Mus and Bulanik, and near

Van. In eastern Turkey cranes are not shy and nearly all pairs have a young. There are many wet places scattered among the extensive dry areas and the cranes apparently can survive there very well.

A breeding place for cranes must be safe and quiet. At least 0.5 m of water is necessary when the cranes are starting to nest. Not only must the nesting spot be safe, but cranes need an area of several hectares around this spot. Cranes stay on the breeding ground for several months and do not like to fly much in that period. For several weeks they cannot fly, because they are molting. In the breeding season cranes mainly eat animal foods, so wet areas are very important.

WINTERING AREAS

The most important wintering areas are in southern Europe, northern Africa, Iran, and India. The locations of these wintering areas are usually the same each year. These areas generally provide good opportunities to protect cranes because the birds are restricted in distribution and can easily be located. These same features also make the cranes vulnerable. Often there is no other suitable habitat in the vicinity. Many common crane wintering areas are famous and have been used for many centuries.

Since last year we know a lot more about common cranes wintering in Spain. Over 10,000 cranes winter in central and southern Spain and in southern Portugal. From the Spanish reports we know that their cranes winter over a rather large area. The feeding grounds and roosts are not always protected. It is possible to develop a protection program using the excellent information that is now available from all the people cooperatively studying cranes in Spain. It is important that the roosts and feeding grounds, such as the open oak-woods, receive protection.

In Tunisia there are 2 main wintering areas, north of Tunis and west of Sousse. Thousands of cranes winter in the areas north of Tunis, sleeping in a few lakes and eating wild daffodils or corn in the corn-fields. The areas west of Sousse (around Lake Kelbia) have been rather dry in recent years, but the cranes still use the area. They sleep on the dry bed of Lake Kelbia and drink at daytime near little wells after the dromedaries have left.

For wintering, common cranes look for areas providing water and extensive feeding grounds. If cranes cause agricultural damage in the future, it will be necessary to look for solutions that allow the cranes to survive. The problems of damaging agricultural areas will become bigger in the future when farmers will no longer be able to sustain these damages. In the Netherlands we have had some experience with crop depredations by wintering geese, and it will be possible with our experience to provide help to farmers receiving depredations by cranes. It generally has to be accepted that numbers of wintering birds should not be allowed to diminish. It is very important that there be enough wintering grounds so the cranes can spread out over larger areas. If too many cranes winter together, there is danger of losses to disease, disturbances, and other factors. Probably the best number of wintering birds on a roost is between 1,000 and 3,000 cranes. Bigger groups are too vulnerable.

MIGRATION STAGING AREAS

We can learn much by studying the staging places. Common cranes use them during migration between breeding and wintering areas. Cranes may stop there for only a night or for several weeks. The areas where cranes rest during several weeks in autumn will be mentioned first. The common cranes of northern Europe gather at Rugen-Bock-Zingst. In a southwestern direction the important areas are Lac du Der-Chantecoq and the southwestern parts of Gascogne, both in France. To the east the situation is more complicated. In northern Poland there are several important small resting places. In Hungary the most important resting areas are in the Puszta Hortobagy, near Kardoskut along the Danube River, and sometimes near Biharugra. In Romania the east coast of the Dobrogea is important.

In September and October thousands of common cranes gather in Turkey. The most important areas in eastern Turkey are around Mus, near Bulanik, near Agri, east of Ercis, and southeast of Van. There probably are 2 flyways, 1 following the Murat Nehri and another east of Van over Cavustepe and south from Urfa. The birds following the Murat Nehri probably migrate over Cyprus, as do the birds coming from Tuz Golu.

With help of the Cyprus Ornithological Society we know much about crane migration in their area. Many cranes are seen in September and October. These cranes winter in northeast Africa.

There are no recent data from Iran, India, and farther east. In autumn cranes have rather permanent staging places, and they are only partially welcome in several of these areas. When the thousands of cranes arrive in September, they can damage the unharvested crops or, if they arrive later, damage the new seeded fields. If the staging areas are large enough there are no serious problems because damage to crops is not concentrated. The shallow parts of the Baltic in the German Democratic Republic (GDR) are the most important staging areas in Europe. It is very important that this entire area be protected by the Ramsar Convention. In autumn 1980 the crane population there reached 18,000. It is an alarming situation. About 20 years ago the same situation existed in the Muritz area of GDR, where over 20,000 cranes rested annually for several weeks. Suddenly all the cranes stopped using the Muritz area and began staging at Rugen.

The problem at Rugen is that the cranes are too vulnerable. By coincidence the water level of the Baltic has been high during the last few years, and many cranes have to look for better sleeping areas around Bock and Zingst. We can only hope that good protection of this area will ensure a future for the cranes. I called this very numerous visited sleeping place an alarming situation. I mentioned also a probably ideal population size in the winter areas (1,000-3,000). For the briefly visited sleeping places the ideal will be probably about 10,000, but larger numbers cannot be managed. It seems now that the entire population of cranes wintering in Spain, Portugal, and Morocco are gathering at Rugen and its vicinity. I hope that some alternative staging areas will be developed within the GDR.

In my last survey for the International Council for Bird Preservation I brought together some data about common crane populations using the resting areas at Rugen, in Poland, and in Hungary. Water is important there but it is not essential. Cranes usually arrive late in the afternoon. If they know the place well,

they come later and stay as long as possible on the feeding grounds. Water plays an important role in the behavior of cranes. Cranes stay on the roost only a short time if there is enough water on both the roost and the feeding grounds. If the habitats are short of water, the behavior is different. If the feeding grounds are dry, the cranes come early to roost. I never saw groups of cranes flying in daytime to drink at large water areas, as geese often do.

As I mentioned about Tunisia and have noticed also at Kardoskut in Hungary, common cranes do not absolutely need water for roosting. They prefer to roost in water, but if they know the place and its safety, they may stay there for a while without problems. The number of cranes staging during marginal water conditions will be less than in normal years. Cranes will stay in such areas for briefer intervals and fly farther south within a few days. For example, the little puszta lake near Kardoskut in Hungary contained enough water for roosting 4 years ago, and 7,000 cranes staged there for several weeks with 70,000 white-fronted (*Anser albifrons*) and bean geese (*A. fabalis*). The next year the lake was nearly dry due to a long, hot, and dry summer. The cranes used the area but the geese did not until 1980, when a small part of the lake again contained water. The cranes then roosted in the water again, although the small surface area would normally have been unfit for a roost. Two hundred geese returned to use the area in 1980.

Among the abovementioned main staging areas there are many placed (moors, heath, riversides, and others) where common cranes stay only 1 night. I do not know how important these areas are for cranes. In spring the behavior of cranes differs because they are in a hurry to return to their nesting grounds. It is necessary to have enough areas where cranes can rest. The new area in northeastern France, as mentioned, is very important and a safe stop between the Pyrenees and Rugen. The management of this area taught us that it is possible to construct an area and attract cranes. An advantage of this new French area is that people can watch cranes without disturbing them.

THE FLYWAYS

Finally, a few remarks about migrating common cranes. Cranes like thermals, but it seems that different species use them in different ways. In a recent article (Pennycuik 1979) you can find more details about this. It is essential that migration pathways for cranes be protected and not threatened by irresponsible shooting. Especially in France and Spain it will be necessary to improve laws and ensure that they will be observed. If the new directive about bird protection does not change the situation in France, it will be clear that this kind of regulation is absolutely worthless. I think, however, we are wrong to buy the hunting rights on the Pyrennes, as was done for 1 little slope. It is impossible to buy civilization; barbarous behavior has to be changed by better education and understanding. Understanding requires better communication and cooperation for a better solution.

CONCLUSIONS

The common crane's habitat is divided into breeding, wintering, and staging areas, and the migration pathways between. The crane's entire environment is more than these parts. Their surroundings are part of our environment, which has value along with the value to the cranes. It will not be easy to maintain abundant cranes in our environment, but it is worth the

effort. I hope that the common crane will be a sign for a better environment in the future.

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NOTES ON THE POPULATION OF COMMON CRANE IN SCANDINAVIA AND FINLAND:
A PRELIMINARY SURVEY¹

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Studies on the migration of the common crane (*Grus grus*) in Scandinavia have been carried out by members of the bird club of Skovde, southern Sweden, since 1967. The studies and some recoveries of banded birds have confirmed that cranes from Scandinavia normally migrate via southern Sweden to Germany south of the Baltic and from there southwesterly through the German Federal Republic and France to southwestern Spain, probably to southern Portugal, and to Morocco.

Returning in spring the cranes assemble in the northern German Democratic Republic to rest at the peninsula Rugen and areas south and southwest of Rugen. In Scandinavia they have only 1 important, regularly used rest area, the marsh Hornborgasjon, 120 km east-northeast of Gothenburg. This resort area is visited by a considerable portion of the Scandinavian crane population. Almost exact counting of the individual cranes resting at this marsh provides a fair idea of the Scandinavian population figures.

At Hornborgasjon 5,500 cranes were recorded in 1967 and in 1968 the total was 5,700. I believe the difference in count between the 2 years was due to better training of the staff in 1968 than in the preceding year when the 1st census was made. Consequently, I conclude that the assembly of cranes at this spring-time resting place had a stable population, and that the same cranes rest there annually even though the stopover varies from 1-14 days.

It was not possible to check the total population in 1969-1972. In 1973 only slightly more than 4,500 cranes were noted, and 4,700 in 1974. The cause for this decrease from 1968 will be discussed later. A negligible number of solitary cranes are occasionally seen migrating through Jutland; thus it appears that almost all of the cranes that nest in Norway migrate through western Sweden.

SWEDEN AND THE SCANDINAVIAN POPULATION

Based on the census at Hornborgasjon in 1968 and a simultaneous inquiry in the mass media, the Scandinavian population in Sweden and Norway was estimated at "more than 10,000 cranes." In the same year the number of cranes recorded passing the German Federal Republic in the spring was about 16,000 (Keil 1970), the majority no doubt belonging to the Scandinavian population. In April 1972, Alerstam and Bauer (1973) made a radar study of bird migration crossing the Baltic Sea from the northern coast of Germany south of Sweden. They concluded that 24,000-48,000 cranes passed and were thought to be the Scandinavian population. Population studies are continuing. The number of nonbreeding birds is considerable; thus the total population mentioned refers to individuals, not to pairs.

There have been no clear-cut changes in the Swedish crane population in recent decades. It is true that considerable differences were noted in numbers of cranes at the rest area Hornborgasjon in 1973 and 1974 compared with the 1968 figures; these changes may relate to changes in the attraction of the area. The

decline in use was anticipated but could not be prevented. An important reason for the unique assemblage of cranes at the Hornborgasjon marsh was the presence of 2 big distilleries. For over 100 years the cranes had extensive potato fields to feed in. When the cranes arrived in early spring to the raw Swedish climate, the frozen potatoes left in the ground when the crop was harvested was the best food available in that part of the country.

A few years ago a national Swedish administration board decided to concentrate all spirit distillery into 1 unit in southernmost Sweden. As a consequence the large-scale potato-growing at Hornborgasjon ended in 1972. The number of cranes in 1972 was not recorded but in 1973 the population was only about 4,500, compared to the 1968 figure of 5,700. The cranes not only decreased in number, but they also scattered to more distant fields where census was more difficult. This scattered distribution was very unfavorable for the investigation and for the average citizen also, who by the 10 thousands visited the marsh to see the cranes dance.

A most remarkable difference was also found in the fall migration of cranes at the island Oland east of the Swedish mainland. There from August to October 1968, 4,170 cranes were counted, with the true number estimated at about 6,000. From August to September 1973, only 2,900 were counted. The migration pattern in the fall of 1973 was, however, greatly aberrant in several other respects compared with what was considered a normal pattern in previous years. The aberration probably was caused by meteorological factors; thus the decrease in numbers may not be significant.

In Sweden, cranes nest from the southernmost province of Skane (occasional pairs in north) to slightly below the timberline in northern Lapland. In Smaland, the province north of Skane, cranes are found as isolated pairs in many forest swamps. In southern Sweden, single pairs breed here and there in open wetlands. The great majority of the cranes in Sweden nest in the vast forest area of the north.

NORWAY, FINLAND, AND DENMARK

In southeastern Norway a small nesting population is found that extends as far north as 64°30'N. In the province Trondelag cranes have increased slightly since the turn of the century. In Denmark only a few pairs have nested in Jutland in the last 50 years. The Finnish population of cranes migrates east of the Baltic Sea. Exceptions may be negligible. Merikallio (1958) estimated the crane population in Finland to be about 8,500 pairs. Considering the future of the Finnish crane population Dr. Olavi Hilden writes (pers. comm.) that "a slow decrease is probably to be expected, because nearly 300,000 ha of wetlands are expected to be drained yearly."

PERCENTAGE OF YOUNG

To learn the percentage of young, we have observed the fall migrants, watching the birds from the beginning to the end of the migratory period. Nonbreeding birds and birds without young arrive early. In August 1976 1.3% of 529 cranes were young and in August 1973

¹Report written in 1974.

only 0.5% of 238 birds were young. The percentage rises until late September. About 5% were young in 1967 and 1968; in 1973 it was 6.7%. In 1973 the migratory pattern was different enough to indicate that several thousand cranes--most of them nonbreeding birds--had chosen another migration route or an earlier migration time.

Twenty-five percent of the adult pairs were accompanied by 2 young. Families with only 1 youngster were 76% in 1966, 73% in 1967, 80% in 1973, and 75% in 1974. I have no data on the number of breeding pairs that lost both of their chicks. Thus the real breeding success remains unknown.

PROTECTION

In Scandinavia and Finland the crane is protected by law. Among the 115 cranes that were banded in Sweden before 1973, 13 were recovered, 3 of them before the start of migration (Sten Osterlof, Riksmuseum, pers. comm.). This number is not unexpected. What is striking is what happened to 21 cranes banded before fledging age over the last 16 years at 1 location in western Dalarna province of central Sweden, all of them obviously belonging to a local population wintering in southwestern Spain. Among those 21 cranes, 4 lost their lives in the 1st year, 1 in the 2nd, and 1 in the 3rd year--thus 28% were dead before probable nesting age. It is alarming that of the 5 cranes that reached the wintering area and were recovered, 4 were shot. Consequently, protection of the cranes may be important in the winter area.

In Sweden about half of the crane population normally uses the island Oland off the east coast as a rest area in the fall. In 1972 and 1973 cranes were severely disturbed at the roost, even after dark. For this reason it has been proposed that the Department of Nature Conservation of the province government take actions to avoid such future disturbance at the roost.

After the decline in potato farming at Hornborgasjön the National Swedish Environment Protection Board and other national boards began working out agreements designed to secure new potato fields for the cranes. As a result, in the spring of 1975, 10 ha of potatoes were left for the cranes to feed on. The cost of that project in 1974 was 43,900 kronor, about \$10,100. This was an initial, experimental phase of protection. Future actions will depend upon further experience and agreements with farmers.

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THE STATUS OF COMMON CRANE IN UPPER LUSATIA

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The nesting area of the common crane (*Grus grus grus*) in Upper Lusatia extends from about 14°E eastward to the Neisse River and south to approximately 51°20'N, encompassing an area of about 1,200 km². In the German Democratic Republic the old land divisions of Mecklenburg, Brandenburg, Saxony, and others are no longer political entities but merely traditional names of general areas. The German Democratic Republic is divided into Bezirke, or regions [as U.S. states] which contain a number of Kreise, or districts [as U.S. counties]. Upper Lusatia is neither region nor district, but an area in the eastern Dresden Region; in the north Upper Lusatia also extends into the Cottbus Region.

The nesting sites in Upper Lusatia lie on the southern fringe of the central European range and continue into Poland to the east. In comparison to the northern and central areas of the German Democratic Republic (Mecklenburg and Brandenburg) there were only a few breeding pairs in Upper Lusatia.

The total population of cranes in the German Democratic Republic is estimated at a minimum of 430-450 pairs, of whom "at least 290, and probably as many as 360 pairs" (Blotzheim 1973) breed in the Mecklenburg Regions of Rostock, Schwerin, and Neubrandenburg. In the Brandenburg Regions--Potsdam, Frankfurt-on-the-Oder, and Cottbus--the numbers are estimated at 120-150 pairs. In the Magdeburg Region about 12 pairs were nesting and in the single breeding area in the Leipzig Region, the Wildenhain Bruch, 4 pairs were known to nest from 1969 through 1971 (and apparently also since then). In the Dresden Region the nesting sites were all in Upper Lusatia in the Kamenz and Bautzen Districts. In the north the Upper Lusatian area included the already mentioned Cottbus Region where there were nesting sites in Hoyerswerda, Weisswasser, and Niesky Districts. Farther north in adjoining Lower Lusatia an additional 20 pairs nested.

In northern Upper Lusatia are numerous ponds, mostly man-made. In 1950 the total surface area of these ponds in Kamenz and Bautzen Districts was 4,500 ha. Improvements and new dredging have added another 500 ha. Adding the Hoyerswerda, Weisswasser, and Niesky Districts, the surface area of ponds in Upper Lusatia is about 10,000 ha. These ponds even today are partly surrounded by a reed zone and a plant-rich transition zone with a water depth of 30 to 100 cm. There also are larger and smaller moors, and swampy, reed-covered meadows in the midst of pine woods.

These reed areas in shallow water and the transition zones of the pond edges are the preferred nesting areas of the cranes in Upper Lusatia. Only a few pairs breed in open moors (Dubringer Moor) and in the smaller wooded moors (Milkeleer Heath, Daubitz). Two pairs nested in swampy fields (Lomischauer Hutung and Kreba); these 2 nest sites, however, have not existed for many years.

The most favorable years for our cranes were those just after World War II. There was absolutely no hunting, the drainage and pond building projects had

not yet been started, and disturbances by all too eager young ornithologists and bird photographers were nil. At that time there were at least 18, very likely 20, and at most 23 pairs of cranes nesting in the above-mentioned districts of Kamenz, Bautzen, Hoyerswerda, Weisswasser, and Niesky.

Although the cranes are thoroughly protected in the German Democratic Republic and have been for years, their numbers in the last 15 years have steadily decreased. In 1974, only 10 or possibly 12 pairs were nesting in Upper Lusatia. Fortunately, the population decline has halted and numbers seem to be stable.

But what are the reasons for the decline in crane numbers in Upper Lusatia? At fault in the decline of our crane population in recent years is the governmental pond management programs wherein ponds have been systematically "improved" with no consideration for the protection of the landscape and the natural environment. The ponds have been largely deprived of the transition zones. In the winter, after fall fish harvests, the ponds are dried out and the reeds and other transition zone plants are bulldozed into high piles in the ponds or on the pond edges. By these measures not only is the natural landscape forever altered but many bird species--not just the cranes--are deprived of their breeding sites for all time, e.g., *Podiceps cristatus*, *P. grisegena*, *Botaurus stellaris*, *Anser anser*, and *Circus aeruginosus*. Two pairs of cranes lost their nest sites via this radical change in the habitat. There has been no instance recorded where these birds changed nesting sites, moving into neighboring pond regions that were still intact.

The second reason, which to be sure has not recently been of such great importance is the lowering of the water table because of large dolomite mines in the middle of this pond region. But this mining also permanently destroyed nest sites. The ponds dried out completely and were abandoned by the cranes. It is naturally very difficult, if not impossible, to determine whether these cranes moved to other areas in Upper Lusatia. A newly spotted breeding pair can be such migrants, yet there is always the possibility that they were previously overlooked.

Two additional nest sites were abandoned because at the start of the breeding season trees were cut near the nest sites and removed from the woods with caterpillar tractors. These are the nest losses for which man is completely responsible. Clutches also are disturbed by wild boars (I observed that on 2 occasions) and on 10 April 1973 a clutch was frozen by a sudden and unusually heavy snowfall, then abandoned by the parent birds. This pair remained in the area for several weeks but appeared to make no attempt at a 2nd clutch.

In the spring of 1973 there were 8 breeding areas in Upper Lusatia with a total of 10 resident nesting pairs. The following spring, 1974, began with sunny, warm weather, and the cranes appeared at their old nest areas. I found clutches both freshly laid and partly brooded on 17 April and on 8 May the first chicks had hatched at 1 nest.

Specifically in spring, 1974, the following breeding areas were occupied--Kamenz District: Milstrich;

¹Translated for International Crane Foundation by Marie R. Oesting. Written in 1974.

Bautzen District: Milkeler Heide, Commerau, Rauden; Hoyerswerda District: Dubringer Moor, Neudorf-Klosterlich (2); Weisswasser District: Nochten; Niesky District: Dauban, Kreba, and Niederspree (2). This accounts for 10 breeding areas with a total of 12 pairs, a slight increase over 1973. Without apparent reasons, 4 breeding areas have been abandoned in recent years.

There is now a great need to protect the crane nest areas that lie in the transition areas at the edges of the ponds. The ponds at Milstrich, Commerau, Rauden, Neudorf-Klosterlich, Dauban, Kreba, and Niederspree must, without question, be exempted from the general pond improvement measures. This should easily be feasible because it deals with only 7 ponds. Compared to the total surface area of the ponds in Upper Lusatia, the ponds proposed for protection are an insignificant portion.

Cranes may be photographed during migration at their rest and staging areas, but not at their nests. There is little fear that brooding cranes will be disturbed by people. The breeding season is early in the year when it is rare to find anyone except for a few pond workers, foresters, and ornithologists in the vicinity of the nest areas of the cranes. Cranes are also very secretive at their nest and, despite the bird's size, are rarely apparent and certainly often overlooked. They are more regularly seen while feeding in the surrounding meadows and fields; the cranes also betray their presence by their call, being heard more frequently than seen. Fortunately, mass tourism has not taken the same form in our area as it has in many other countries, so the cranes are not disturbed at their nest areas.

The expression used so frequently, "endangered species," is not quite fitting for our crane. It would be more correct to describe our crane as "threatened

with extirpation." In any event it is man who--generally unknowingly and without concern for the consequences of his actions--causes the gradual disappearance of a bird species. Our common crane is not endangered in its entire breeding territory. However, that should not prevent us from doing everything we can to save the small population of nesting pairs in highly populated central Europe. But such preservation is only possible if we maintain the breeding habitat--that is, the transitional areas on pond edges, the moors, and the swampy meadows--in its present condition.

Agriculture and aquaculture must be prepared to forsake a few hectares of usable surface area in the interest of crane protection. Only then can we hope that the present population of 12 breeding pairs will remain in the coming years.

Crane pairs return to their old nest sites year after year and stick to them with remarkable tenacity. It is possible that 1 or another of the nest sites of former years will be reoccupied if the habitat is not too changed by human interference. This is true, for example, of the large pond area near Kreba. Right after the war there were regularly 4 pairs breeding there. Today, unfortunately, only 1 pair remains.

The breeding sites of our cranes are as threatened as ever because commercial development--aquaculture and dolomite mining--is accorded 1st priority. For some time now the dolomite mining and improvements in the ponds have come to a halt but neither has come to an end; there was simply a pause necessitated by economic factors.

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COMMON CRANES IN THE GERMAN FEDERAL REPUBLIC

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The last nesting habitats of the common crane (*Grus grus*) in the German Federal Republic (DFR) are located near the border of the German Democratic Republic (DDR) in the States of Schleswig Holstein (Lander) and Niederschwen (Lower Saxony). These 2 states contain 3 crane breeding areas and the birds are thought to be extensions of the westernmost crane populations in the DDR. Some crane pairs vary their nesting locations, nesting on opposite sides of the border in different years. Thus it is difficult to determine the exact number of breeding pairs of the West German population.

In 1900, 30-35 pairs were counted at 30 breeding locations in Lower Saxony. After 1945 the Department of Farming and Forestry drained the wetlands along the DFR-DDR border and nesting habitat dried out. Despite these changes some crane pairs still nest there. In 1974 there were only 10-12 pairs breeding at 12 locations.

The Vogelschutzstation Luneburg (Field Center for the Protection of Birds) has been managing a conservation and research program for cranes since 1950. This program was enlarged in 1973 with the founding of a Conservation Group for Cranes (CGC). The CGC tries to help the pairs by deepening wet areas and by damming streams to produce areas of shallow open water. Group members live near all breeding areas of cranes in the DFR. The CGC are members of local associations for bird protection and local experts about cranes. The World Wildlife Fund-Germany gives financial support to CGC activities.

Since 1973 CGC has discovered that the successful nesting of cranes depends on the following conditions:

1. Breeding pairs require wetland habitat in which the water must be almost 30 cm deep.
2. The cranes require wetland in which to nest. The wetland should be large enough so that an alternative nest location is available if the birds are disturbed at the 1st nest site.
3. Disturbances should be prevented, particularly during the prelaying period and the 1st 2 weeks of incubation.
4. The populations of wild boars (*Sus scrofa*) must be reduced drastically in crane habitat.

STATUS IN 1974

Six breeding pairs and 1 nonbreeding pair were established on territories in Kreis Herzogtum Lauenburg (Schleswig Holstein). Two pairs lost their eggs and 5 young were observed in June. Kreis Louchow-Dannenberg (Niedersachsen) also had 6 breeding pairs and 2 non-

breeding pairs, 1 of which occasionally crossed the border into DDR. One pair lost their eggs and 7 young were observed in June. In the 3rd nesting region, Kreis Gifhorn (Niedersachsen), only 1 pair nested but 3 nonbreeding pairs were present. In summary, DFR had 19 pairs of cranes in 1974 of which 2 or 3 pairs occasionally crossed the border into DDR.

CONSERVATION OF BREEDING HABITATS

CGC asked the official Administration for Conservation of Nature and Landscape Planning to declare the 3 breeding areas as strictly protected nature reserves (Naturschutzgebiet). Four regions were purchased by the County Department and the Forest Department from private owners. With financial help from the World Wildlife Fund-Germany the CGC dug out new marshes and dammed up the water level at 3 nesting sites. Two nesting marshes were cleared by mowing emergent reeds and cutting birches. CGC also undertook the first experiments to create new marshes using dynamite.

To prevent disturbances by photographers, the CGC influenced the hunting authorities of Lower Saxony to prohibit taking photographs and sound recordings at the breeding place. Permission to take films of cranes on the nest will be given only after consultation with CGS.

The breeding regions in Kreis Herzogtum Lauenburg were threatened by farming activities. In lengthy discussions with officials of the district's farming department, the CGC tried to prevent the disturbance of nesting habitat. In the same area, the CGC observed the deterioration of the breeding habitat of 2 pairs. A gravel mining operation takes water from the crane's lake for washing gravel. After washing, the silt is pumped back into the lake so the lake is filling in and its swampy beach region being reduced. CGC has been unable to prevent the company from taking water from the lake but the Nature Conservation Office ordered that the water must be desilted before it is pumped back into the lake.

INFORMATION FOR THE PUBLIC

Reports about the activities of the Crane Group were presented nationwide in 4 television films. I produced 2 films, "Refuge in Swamps" and "Holes in Noah's Ark." Heinz Sielmann produced "Cranes" and Eugene Schumacher produced another film of the same name. In connection with the World Wildlife Fund-Germany and Deutscher Naturschutzring, a leaflet was distributed that lists guidelines for protecting rare birds such as cranes. The Vogelschutzstation Luneburg also constructed an exhibit about World Wildlife Fund projects in Germany, a display that provided detailed information about the crane project. The exhibit was shown in several areas of West Germany.

Black-Necked Crane



Photo by G. Archibald.

BLACK-NECKED CRANE: A REVIEW

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The least known of the world's cranes is the large black-necked crane (*Grus nigricollis*) of the Tibetan Plateau. It inhabits the earth's most physically and politically impenetrable area (Fig. 1). Even before the Chinese occupation of Tibet in 1950, few foreigners were allowed entry into this mysterious top-of-the-world country where all living things were protected by the Buddhist faith. The last record of black-necked cranes in the wild we were able to find was a sighting in 1948, and it is the only species that crane specialist Lawrence Walkinshaw has been able to study in the wild. From 1968-1974 we attempted to obtain information on the world's only alpine crane species. This report includes the meager results of our labors.

The black-necked crane was the last of the world's cranes discovered when, in 1976, the great Russian naturalist-explorer Prjevalsky sighted several pairs near Lake Koko Nor in northeastern Tibet. In the intervening century there have been only a few scattered reports of the species, the most comprehensive of which was a 3-page article by Ernst Schafer in 1938. No report of wild black-necked cranes has been published in the last 26 years.

This frustrating state of affairs should perhaps be put into perspective. The physical obstacles alone are cause for dismay. To approach the Tibetan Plateau from India in the south means to traverse the Himalayas; the "passes" are 3,000 m and higher. An approach from the north following the route that Prjevalsky took is scarcely better--the great Gobi Desert must first be crossed. A western approach is possible only by following the river systems just north of the greatest height of the Himalaya Mountains, from northeastern Kashmir along a crescent-shaped route to Lhasa, Tibet's capital. None of these rivers is navigable; in summer they are raging torrents from snowmelt water, and travel in Tibetan winter is, when at all possible, extremely hazardous. An approach from China in the east involves crossing countless rivers and mountain passes. Any of these approaches until quite recently was via caravan track, on the back of a yak.

Having reached the Tibetan Plateau, conditions were not much better--vast barren sand plateaus, blinding sand and snow storms, and extreme cold. Tibet is largely uninhabited--indeed uninhabitable. Lhasa is considered to have a favorable climate with its July average a chilly 58°F. Cultivation is feasible only along the southern rim of Tibet, even then barley is almost the sole crop possible. Trees are nonexistent except along the southern and eastern fringes; dung chips provide fuel for fires in most of Tibet.

Adding to these physical problems are the political barriers. Before the Chinese occupation of the Tibetan plateau in the 1950's, the people of Tibet forbade all but a very few outside travelers. At the time of the Dalai Lama's 1979 flight to India there were only 6 foreigners in all of Tibet. All requests for travel permits were ignored, and the main function of the Tibetan army was to turn aside curious outsiders. Except for the British military personnel from the Younghusband expedition in 1904, probably less than a hundred westerners were allowed entry into Tibet. Even with permission to enter it was not always easy to proceed, as the 2nd Dolan expedition discovered when its travel permit was abruptly lifted not far from Lake Koko Nor after the party had already been marching for several months.

As far as we can determine, no westerner gained access to Tibet after the flight of the Dalai Lama, in 1950, until 1980 when the Chinese permitted a group of western ecologists to travel there. The Chinese have been building airfields and roads into Tibet from the east. Wheeled vehicles are now found in Tibet; thus, travel has improved. However, recent reports of cranes in Tibet are nonexistent.

DISTRIBUTION

The black-necked crane reportedly breed in Ladak (Osmaston 1927), in the vicinity of the upper reaches of the Indus River in southwestern Tibet (Ludlow 1920, Meinertzhagen 1927, Ali 1947, Lavkumar 1955), in areas bordering the Brahmaputra River in southern Tibet (Bailey 1911, Hingston 1927, Ludlow 1927, Meinertzhagen 1927, Battye 1935, Walton 1946), and in northwestern Szechwan Province of China (Schafer 1938, Dolan 1939). In March of 1876 Prjevalsky found pairs near Lake Koko Nor in northeastern Tsinghai Province of China, which suggests that the species probably breeds between Szechwan and Koko Nor. Although no breeding records exist for the vast Tibetan Plateau between Ladak and Koko Nor, Schafer (1938) saw migrant flocks at Jalung in south-central Tibet and near Seshu (northwestern Szechwan). The birds were probably migrating between southern wintering grounds and breeding areas in the central plateau. Black-necked cranes have also been seen in migration at Litang (western Szechwan) (Dolan 1939) and in central Yunnan (Stevens 1930).

Large winter flocks are reported in south-central Tibet (Bailey 1910, Ludlow 1927, Walton 1946) and in southwestern Szechwan and northwestern Yunnan (Schafer 1938, Dolan 1939). A single small flock wintered for years in northern Assam's Apa Tani Valley (Betts 1955). Delacour (1927) reported a few birds in Vietnam on the Plain of Hanoi and in the province of Hadong.

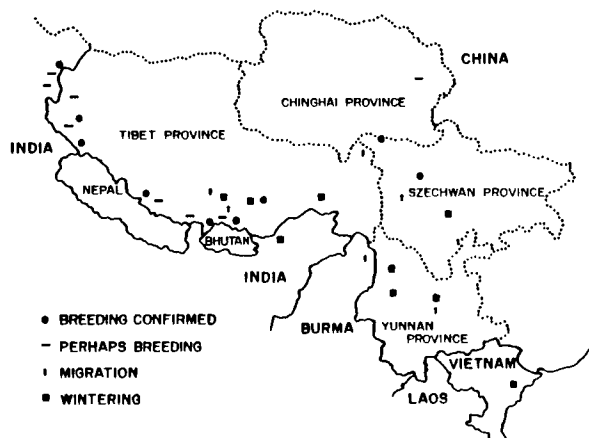


Fig. 1. Historical distribution of the black-necked crane.

In summary, we are aware of only 9 definite nesting locations, 8 areas where pairs are presumed breeding, 6 locations where migration has been reported, and 9 wintering sites (Fig. 1). This fragmentary data suggests 2 distinct distribution areas: a western area where the birds are either sedentary or longitudinal and altitudinal migrants, and an eastern area where the population is perhaps sedentary or latitudinally migratory.

The western distribution area is a rather crescent-shaped series of known breeding and wintering grounds from Ladak in the west, skirting along the north of the Himalayas to eastern Tibet. Nesting areas are located throughout the crescent; however, known wintering sites are reported only from its eastern end near Gyantse or just east of Lhasa. Walton (1946) reported that the cranes winter and breed near Lhasa, suggesting that some black-necked cranes are sedentary. Ornithological investigations have not been undertaken in Ladak and southwestern Tibet in winter; consequently, we do not know if those cranes winter along the river valleys there or if perhaps the huge winter congregations of cranes in southeastern Tibet are partly made up of birds that migrated in from the west.

The eastern area of black-necked crane sightings encompasses a huge territory stretching from Lake Koko Nor in the north, south through western Szechwan, down the Yangtse River valley to the plains of Yunnan, and as far south as the Hanoi lowlands. In this area breeding is known only in the north--southern areas are specifically wintering grounds.

Schafer (1938) and Dolan (1939) reported large flocks of cranes wintering in western Szechwan's Plain of Litang, and Dolan described numbers of black-necked cranes breeding in the same general area, but slightly northeast in the Dsachu Steppe. These reports suggest that there are also migratory and sedentary populations in western Szechwan. Perhaps the cranes from Koko Nor and northern Szechwan migrate through the sedentary population of west-central Szechwan and continue to the major wintering areas in Yunnan and marginal areas in North Vietnam.

A remarkable trait of the black-necked crane is its preference for high altitudes. Its nesting areas are between 3,962 and 4,571 m (13,000 and 15,000 feet) above sea level, and even in winter it is the exception for birds to migrate to warm lowland areas. In contrast to other waterfowl in the western crescent, these black-necked cranes do not migrate over the Himalayas to the luxuriant plains of northern India. The small flock in the Apa Tani Valley of Assam is the only population known to regularly even enter the valleys of the south slope of the Himalayas.

The only other report of this species wintering in Himalayan valleys outside Tibet is a 1971 correspondence with the King of Nepal, who reported black-necked cranes in the Kathmandu valley every 12 to 15 years in particularly harsh winters. Even in western Szechwan the cranes do not migrate into the province's eastern and warmer lowland Red Basin (Schafer 1938). Delacour and JaBouille (1931) report a few blacknecks in Vietnam near Hanoi and in the province of Hadong--contrasting to Schafer's reports of thousands in western Szechwan--indicating that the winter occurrence of these cranes in North Vietnam is an exception to the migratory behavior of the species as a whole.

We should keep in mind that tens of thousands of demoiselle (*Anthropoides virgo*) and common (*Grus grus*

lilfordi) cranes, breeding north of the black-neck areas, migrate through, and winter to the south of, the range of the black-necked crane. Schafer reports that the southern winter limits of the black-necked cranes in western China border the northern winter range of the common cranes. Schafer considered the black-necked cranes restricted migrants--"more a bird of passage than a migratory bird in the true sense."

HABITAT

Black-necked cranes breed on tundra-like marshes and bogs around the margins and on islands of lakes in the Tibetan steppes (Osmaston 1925, Ludlow 1928, Schafer 1938, Ali 1947). A superficial examination of any atlas reveals that most of Tibet is an uninhabited mosaic of lakes and marshlands, most of which have never been investigated by scientists. An example is the Tsaidam Swamp of northeastern Tibet--a huge wetland, about the size of Massachusetts, at relatively low altitude (2,743m [9,000 feet]). Perhaps the Tsaidam Swamp is the breeding area for some of the thousands of black-necked cranes reported by the 2nd Dolan expedition (Schafer 1938, Dolan 1939) to migrate through western Szechwan.

The Tibetan wetlands were graphically described by Schafer (1938), who reported numerous nests in areas so inaccessible that the birds could be observed only with great difficulties and peril. The weight of a man is enough to sink him at least to his hips as he tries to wade through the bogs and marshes.

The cranes' winter habitats in southern Tibet and western China are cultivated areas where the cranes feed on the remains of the previous year's harvests (Stevens 1930, Betts 1954). At that season they roost in flocks at night in marshy areas or in the shallow river waters (Ludlow 1944, Betts 1954). However, winter observations of cranes are most difficult due to the severe climate. Ludlow spent a winter in south-central Tibet where many cranes had congregated. He described it foray. "What a terrible enemy the wind is in Tibet . . . To be caught in a Tibetan blizzard in mid-winter is an experience no one ever forgets. You may wear all the woolen clothes in your wardrobe and you will be chilled to the bone. You may swathe your face in a mask or muffler, wear the most wonderful dust-proof glasses ever fashioned, and it will be of no avail. Your eyes, mouth, nostrils will be choked with sand, your breath will freeze, and the icy spicules on your mask or muffler will sear your face like sandpaper." And Ludlow was describing the warmest part of Tibet.

It is no wonder that few winter sightings are known--even for "milder" areas near larger settlements. We know absolutely nothing about the black-necked crane's relationship with the numerous natural hot springs that dot the Tibetan Plateau. Perhaps the birds frequent these springs during the harsh winter months.

BREEDING BIOLOGY

In Late February and early March the cranes migrate from their wintering grounds (Betts 1954). Migrants arrive in western Szechwan in mid-March (Schafer 1938) and in Koko Nor by late March (Prjevalsky 1876). Schafer considered the western China migration complete by mid-April.

Birds arrive on the breeding grounds as mated pairs (Schafer 1938) and have then been observed in nuptial displays (Ali 1947). In south-central Tibet and in

Szechwan, eggs are laid from late May to mid-June (Barker 1928, Ludlow 1928, Schafer 1938). In southwestern Tibet and eastern Ladak, where spring comes later, nesting begins in mid-June and continues into July (Osmaston 1925, Meinertzhagen 1927, Ali 1947). Schafer describes the males as much bolder than the females as they begin the breeding season. However, both adults are very cautious as soon as the eggs are laid.

They have a variety of nest sites--from a mere scrape on a small island (Dresser 1906, Ludlow 1928, Schafer 1938), to a construction of reeds (Ali 1947), which they reputedly reuse from 1 year to the next (Osmaston 1925), to a mud-formed flamingo-like nest (Schafer 1938). Bailey (1910) observed *G. nigricollis* nests within nesting colonies of bar-headed geese (*Anser indicus*). Marsh vegetation on many Tibetan wetlands does not start to grow until July; consequently, the crane nests are obvious, especially those on small islands.

However, the cranes have an effective method of leading humans from their nests. Schafer noted that when he would approach within 300 to 500 m of the nest the incubating bird would sneak off the nest and, while crouched, run from the area using every little upcrop as a visual block from the intruder. Then after the crane had secretly followed the intruder for some distance, it suddenly appeared close at hand and tried to lead the observer away.

By September the chicks in western Szechwan are capable of flight, although they are much smaller than their parents (Schafer 1938). They gradually gather in flocks of as many as 100 birds and move to warmer areas as the intensive cold weather threatens (Schafer 1938). Ludlow (1944) reports the birds are never very social in south-central Tibet; however, he observed 1 flock of 200 on 21 March, undoubtedly migrant birds. La Touche (1924) described blacknecks as remaining separate from flocks of common cranes in winter grounds in western China. By the end of February the migrants to Assam's Apa Tani Valley become restless. Betts (1954), describing nuptial displays, which begin at the onset of the breeding season, said, "The flock would be feeding quietly, when suddenly they would all burst into a chorus of trumpeting, and first one and then another would start to prance and caper."

CAPTIVE BLACK-NECKED CRANES

Taka-Tsukasa (1925) reports that black-necked cranes used to be imported from China to Japanese zoos. La Touche (1924) saw a couple of live specimens in captivity at the Governor's Garden at Yunnanfu, western China, in 1921. Delacour and JaBouille (1925) trapped 2 cranes at Hadong, North Vietnam, and exported them to Delacour's collection at Cleres, France. On the day of his escape from Tibet in 1959, the current Dalai Lama refers in his autobiography to "white cranes" beside a pond at his summer residence, Norbalinka, near Lhasa. Presumably these were captive black-necked cranes. In 1973 Shiro Nakagawa (pers. comm.) saw 2 specimens at the Peking Zoo and 3 at the Shanghai Zoo. The bird has never been reported to breed in captivity.

POPULATION SIZE

In 1925, Delacour and JaBouille reported black-necked cranes wintering near Hanoi, but his later reports (Delacour et al. 1928) mention only 1 bird there, so the population of Vietnam wintering cranes is somewhat uncertain. Delacour and JaBouille (1925)

also stated that there were large numbers of these cranes in Tibet. This opinion concerning their Tibetan numbers is shared by Hartert (1921-22), Ludlow (1928), and Walton (1946) for areas near Gyantze and Lhasa in south-central Tibet--particularly thousands of birds in the Kyi-tschu Valley around Lhasa and in the Brahmaputra Valley between Samyea and Yalong Po-drang (Schafer 1974, pers. comm.). Dolan (1939) reported thousands of cranes on the winter grounds in western China and the breeding grounds on the Dsachu steppes of Szechwan. In 1973 a Chinese zoo technician told Shiro Nakagawa (Nakagawa, pers. comm.) that these cranes are "not so rare" in the wild.

TIBETANS AND THE CRANES

For hundreds of years the Tibetans were intensely Buddhist in faith. As Buddhists they revered all forms of animal life and considered the taking of any animal's life a great clash with their belief. The Tibetan form of Buddhism--often called Lamaism--developed a means of accommodating this sacredness of life with the food needs of people living in an extremely harsh climate. Lamaism declares that although the taking of life is sinful, eating meat after the animal is dead is not sinful, but practical. Thus, Tibetans eat milk, butter, eggs, yak, dzo, and chicken. The sacredness of living beings did, however, preclude slaughter of wildlife. Thus, in many areas black-necked cranes were abundant and quite tame (Meinertzhagen 1927, Ludlow 1928, Ludlow 1944, Betts 1954).

With the influx of Chinese people and ideals into Tibet since the 1950's, Buddhist doctrines have become less dominant and there is an increasing tendency to use wildlife as an economic resource.

In the past 30 years Tibet has changed from a feudal agricultural society into a 20th century machine society, with roads, airfields, hydroelectric dams, and mechanized agriculture--all of these factors have drastically altered the landscape of the Tibetan Plateau. We do not know how much of the breeding and wintering habitat of black-necked cranes has been destroyed by flooding from dams or by drainage. The Chinese have expressed concern for their wildlife by establishing sanctuaries for the giant panda (*Ailuropoda melanoleuca*) in Szechwan and for red-crowned cranes (*Grus japonensis*) in northeast China. It is hoped they are also preserving habitat for the black-necked crane.

INFORMATION-GATHERING ATTEMPTS

We wrote many letters while researching this report. For post-1948 data on the black-necked crane, we have only 2 responses. The first is from an interview with Geshe Sopa, a Tibetan refugee who accompanied the 2nd flight of the Dalai Lama in 1959. Mr. Sopa stated (7 February 1974) that the black-necked crane or Trung-trung is found mostly in southern Tibet near water and was seen most often in winter, when it moved into the inhabited valleys. The 2nd comes from Shiro Nakagawa, director of the Ueno Zoo in Tokyo, who visited China in 1973 and was told by Chinese zoo technician that the black-necked cranes are "not so rare" in the wild. The following are responses to our request for information concerning the black-necked crane.¹

¹These letters have been edited to ensure clarity and to improve their English in order to avoid embarrassing correspondents who were unaware their letters might be published.--J. Lewis.

17 August 1971

I do not know how you could get into the Apa Tani Valley. From there is the only record of G. nigricollis that I can recall from our region (I use "our" in a proprietary sense because I have been working on Indian birds since 1947). The Apa Tani area is in the Dafla Hills, known as the North-East Frontier Agency, an area off limits to Europeans and most Indian citizens. Even the Governor of Assam would have great difficulty getting an outsider in.

Dr. S. Dillon Ripley
Paddling Ponds
Litchfield, CN 06759

5 September 1971

The crux of the matter, however, is your first question--do the cranes ("kenga" in Apa Tani) still winter in the Apa Tani Valley? That, I am afraid, I cannot tell you, but I am also afraid that the odds are very much against it. The whole Valley is only 52 km² and the paddy fields where the cranes lived and fed were less than half of that. The cranes were comparatively fearless of the 20,000 Apa Tanis who lived and worked in the fields, but even then anyone not in Apa Tani dress could not get within 0.8 km of them. With the appearance of outsiders and soldiers with firearms, aircraft, and motor transport there is a very grave risk that the birds have either been shot or scared away. As well as I can ascertain this was the only spot in India where these cranes occurred and of course their summer quarters in Tibet are quite inaccessible these days.

Col. F. N. Betts
Stocks Cottage, Burley Street
Nr. Ringwood
Hants, England

21 October 1971

I have delayed answering your letter of 15 September until I had a chance to speak to Dr. Furer Haimendorf about his recent visit to the Apa Tani area. He could give me no news of them. He did say, however, that the actual habitat and methods of cultivation were very little changed so that there would be plenty of fallen grains to glean after reaping by hand, and frogs and insects in the irrigation ditches. But with the advent of roads, motor transport, and firearms I am afraid the risk of unacceptable disturbance is very great.

Col. F. N. Betts
Stocks Cottage, Burley Street
Nr. Ringwood
Hants, England

16 April 1974

I have travelled the steppes in eastern Tibet around the sources of the Yangtse River. This was the main breeding area of G. nigricollis. I do not think that it breeds in the lower, warmer, and wetter regions of eastern Tibet. I also found the bird breeding at 4,700 m north of the Bhutan-Himalaya. Thousands of G. nigricollis wintered in the Kyi-tshu Valley around Lhasa and in the Tzangpo Valley between

Samyea and Yalung Podrang. As you know from my former publications, G. nigricollis also winters in the Yunnan Province of China . . . I have no recent reports of the species, but I believe that the bird is still common in high Tibet.

Mr. Ernst Schafer
3133 Gohr-Post Schnega
Federal Republic of Germany

27 August 1971

Approximately every 12 or 15 years, when pursued by storm, they seem to stay in Kathmandu Valley or at Tarai areas only 1 or 2 days on their way. Hence, there is very little chance of your studying this species in Nepal.

Ishwari M. Shrestha
Principal Private Secretary to
the King of Nepal
Royal Palace, Nepal

31 October 1973

As for cranes, I saw the following: Peking Zoo--3 Grus nigricollis; Shanghai Zoo--2 G. nigricollis. This was the first time I ever saw G. nigricollis. A Chinese zoo technician said the cranes are not rare in the wild. Therefore, the Chinese zoos are not too eager to artificially breed these cranes.

Dr. Shiro Nakagawa, D.V.M.
General Curator of Animals
Ueno Zoological Gardens
Ueno Park, Taito-ku
Tokyo, Japan

24 September 1974

Anyone reporting this species in Nepal must have seen the black-necked stork (Xenorhynchus asiaticus) in Kathmandu Valley. We have no record of your crane for the Kingdom of Nepal.

Robert L. Fleming
Box 229
Kathmandu, Nepal

17 September 1974

My only data on Grus nigricollis are hearsay. I talked to an Indian army officer stationed in northern Assam, who said that cranes were still coming there. That was in December 1972. It is kind of feeble evidence. He did seem to know the birds.

Ben King
Ornithology Department
American Museum of Natural History
Central Park West on 79th Street
New York, New York

5 August 1974

The black-necked crane was never observed wintering in North Vietnam while the bombing was going on, but since the war is over many of the birds have come back to winter in the vicinity of Hanoi and elsewhere in the Babco delta.

Vo Quy, Ornithologist
via: Nguyen Van Thu, Subdirector
Central Library for Science
and Technology
University of Hanoi
Hanoi, North Vietnam

16 August 1974

It is now quite certain that small numbers of black-necked cranes winter in central and eastern Bhutan, but unfortunately I did not see them last autumn before we left the upper valleys in early November. I suspect that as many as 200 winter in the narrow river valleys from Punakha east to Bumthang and Tashigang (3 river valley systems altogether), at an average altitude of 1,525 to 1,830 m (nearly 2,745 m in the Bumthang Valley), and that there are fluctuations in number and vagrant occurrences from valley to valley each year. They feed on the barley fields in the daytime, and spend the nights on small islands in the rivers, islands of low willow scrub and high grass.

They are apparently rather tame, and undisturbed, and I am not sanguine that it would be very easy for you to get permission to visit these areas. The weather is particularly damp and chilling at that altitude along these river valleys in December and that is why, aside from the remoteness of the place and the difficulty of getting permission to visit, that there have been no reports of the crane up until now. When I say 200 birds, I am of course being conservative. The reports that I have received indicate a concentration some years in the Bumthang Valley (which is broader) of perhaps 200 all told, with very small concentrations, 12 or so birds, in either of the valleys to the West (Punakha) or east (Tashigang).

There is another small valley intermediate, upriver from Tongsa, between Punakha and Bumthang, and it is quite likely that there may be other possible grazing and wintering grounds for a few cranes along those riverbank fields, because there are ponds, small hot springs, and Tibetan-like facies here and there in the upper reaches of these streams. The altitude would never be less than 1,525 m, however, and presumably more likely, birds would stay much higher--up to 3,050 m, just as across the ridges in Tibet.

S. Dillon Ripley, Secretary
Smithsonian Institution
Washington, D.C. 20560, USA

25 September 1974

I am not very sure that the information we have, which would not be conscious, deliberate investigation but merely secondary observation, would be very helpful, but here it is, for what it is worth.

. . . The black-necked crane (*Grus nigricollis*) is not the most common of cranes to be seen. For instance, the demoiselle crane we used to see in the Nam Tamai Valley (eastern headwaters of the Irrawaddy) in fall, disappeared before winter, apparently migrating south. But you are correct that the black-necked crane winters in north Burma. It is in the western area and in the Triangle area of Kachin Hills, between the Mali Hka and the Nam Tamai Valleys, and they would be seen briefly en route, at different points in the Nam Tamai Valley, near the areas where there are lower passes over the high north-south watersheds, e.g., specifically at 26°53'N by 98°18'E.

There are available here roughly half a dozen "natives" besides our family, who have been in . . . the Tarung Hka Basin, the main headwaters to the Chindwin River of northwest Burma. I have checked with all of them and must report that this information is most casual. We have observed the following facts: Never noticeably seen in flocks, yet they are common in winter all along the streams, where theirs are the most common tracks. Thus, a person going down along the streams might notice 10-20 cranes in a morning's walk, or as many as 50-100 in a day's walk along a stream. They did seem to be more plentiful at times on the lower Tarung Kha. Actually, this is also the wintering grounds of several kinds of hornbill, which would be seen in flocks of thousands, thus making the presence of cranes or other birds rather insignificant. We cannot remember if there were any other crane species present. What we do remember is seeing the black-necked cranes in pairs.

The cranes were seen only in winter or in summer; we cannot identify all the specific months to indicate the overall time, but we did notice them in November, December, and January. They were quite plentiful in November--sparse in October. They were never seen with small chicks, but often yearlings could be distinguished from the adults. No nests or nesting places were ever seen. . . .

They were mostly seen along the streams, and we assume that they ate little fish, the crawfish that are so plentiful, and a small local fish ("ngalong"), which is highly prized as food by all birds, animals, and humans. . . . Unfortunately none of us can remember other aspects of their behavior, or their calls or duets, except several of us remember the surprise of, very rarely, seeing some of these supposed water birds flying up from a tree, up on a hillside

The black-necked crane is referred to by the Lisu as "the epilepsy bird," or some equivalent: ni-cin-nya, "demon-convulsion-bird." This originated from the coincidence some time in the distant past of a person having epileptic seizures after killing and eating such a bird. This occurrence would suffice to start such a tradition. In any event, it would only be those persons ignorant of this tradition that might kill this bird for eating purposes These birds are thus very rarely shot. . . .

Since the mountain peaks or high ranges are too far away and high up to have people able to observe, we cannot say whether the cranes fly straight over the mountains or not. However, the assumption is that, as with all the other birds that migrate, the cranes also follow the path of least resistance, meaning the air currents, and follow the line of the rivers and valleys. . . . I do not remember ever seeing either the sarus crane (*G. antigone*) or the black-neck or others, in either the Salween or Mekong or Yangtze Valleys during the winter migrations--only in Burma. In December 1973, Konglang Dvgong observed huge migratory flocks of the black-necked crane towards evening, along the shores of the Mali Hka River east of Putao at 27°20'N by 97°34'E, in flocks of between 50-100. There were also, separately, smaller groups of the sarus crane. These would have come down from the Mali Hka headwaters, having crossed over the high ranges from the Lohit-Zayul Basin at any of the several lower passes. Here in the Mali Basin, where the "ngalong" fish is not prevalent, the birds were observed to nibble at the mosses, lichens, and grasses. Even here, where the country is open and flat, with fields along the edges of the streams, the birds seem to avoid the fields and keep to the riverbanks.

Robert H. Morse
North Thailand Christian Mission
40-8 Tungwe Salee
Cheingmai, Thailand

11 November 1974

Dr. Biswas . . . travelled eastward and saw small numbers of both the black-necked crane and demoiselle crane in harvested paddy fields in east Bhutan (Tashi Yangtse area at about 2,000 m in early December). So a trained ornithologist has sighted *Grus nigricollis* in east Bhutan in 197?. We had of course assembled some information about the incidence of the crane in winter in the Bhutan valleys with the largest concentration being in the Bhumthang Valley.

S. Dillon Ripley, Secretary
Smithsonian Institution
Washington, D.C. 20560, USA

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BLACK-NECKED CRANES IN LADAKH

PRAKASH GOLE, World Wildlife Fund--India, 277 Sindh Honsing Society, Poona 411 007, Maharashtra, India

Initially the "Ladakh phase" of the black-necked crane (*Grus nigricollis*) study project was to include a study of the breeding biology of the crane and collection of 12 eggs for captive breeding. But in his first report on the wintering population of black-necked cranes in Bhutan, Lavkumar Khacher said that the study of the breeding biology of these cranes and collection of eggs for breeding in captivity might not prove feasible in 1978. Therefore, he decided to attempt in 1978: (1) A survey of all the possible nesting areas of cranes to assess the number of breeding pairs in Ladakh, and (2) a study of their breeding behavior if a suitable nesting area was found.

Ladakh is reputed to be 1 of the most elevated inhabited regions in the world. Parallel mountain ranges run from southeast to northwest; between the mountains are level, gravelly plains and several landlocked, brackish lakes and pools. The Indus River flows northwest through Ladakh (Fig. 1).

The climate is most unusual, burning heat by day followed by piercing cold at night. The mean temperature of the elevated region of Rupshu (4,527 m) is -1.1°C and during the day the temperature may rise to 17.8°C. In May, water froze every night. Extreme dryness of air is another characteristic of the climate. This is due chiefly to elevation; the air is rarified and incapable of holding much moisture in suspension. The dryness is also partly due to the great radiation of heat from the bare soil, by which any moisture is rapidly evaporated.

ARRIVAL IN LEH

The cranes were reported to migrate from their wintering grounds at the end of February or early March

and, therefore, were expected on their breeding grounds in April. The town of Leh was reached by air from Ambala on 24 April. We hoped that the cranes had preceded us and had by then settled down to the serious business of nesting.

Several days were spent in Leh, acclimatizing and organizing transport, equipment, and food with the help of the army and Jammu and Kashmir Forest Departments. We attempted to collect as much information as possible about the sites normally visited by these cranes, mainly with the help of Shri Deshpal, Game Ranger in Leh. A number of people were consulted to ascertain the exact location of extensive marshes and favored grazing grounds of sheep because, during the preliminary survey in 1976, the cranes seemed to prefer such areas. In 1976, crane pairs were seen in the vicinity of marshes in Chushul and Hanle. Besides these 2 places the cranes had been reported from Chumar, Purple Mountain meadows near Hanle, Tao Kar near Dungti, a marsh near Thugje Gumpa, and the Howrang marsh near Tangtse. We also decided to visit Tao Moriri and Starsapuk Tao because cranes were reported from both those places in 1930's. The latter 2 lakes (Taos) are also the well-known breeding habitat of the bar-headed goose (*Anser indicus*) and other waterfowl. We believed that as a follow-up of the survey of 1976 it might be useful to visit these lakes to assess the number of waterfowl breeding in Ladakh.

Spring followed as we set out of Leh on 3 May. House sparrows (*Passer domesticus*) and common redstarts (*Phoenicurus phoenicurus*) had arrived and magpie (*Pica pica*) pairs were searching for suitable nest sites. Exquisite tiny leaves were unfolding on the willow branches and the song of the chiffchaff (*Phylloscopus collybita*) resounded in the prickly Hippophae

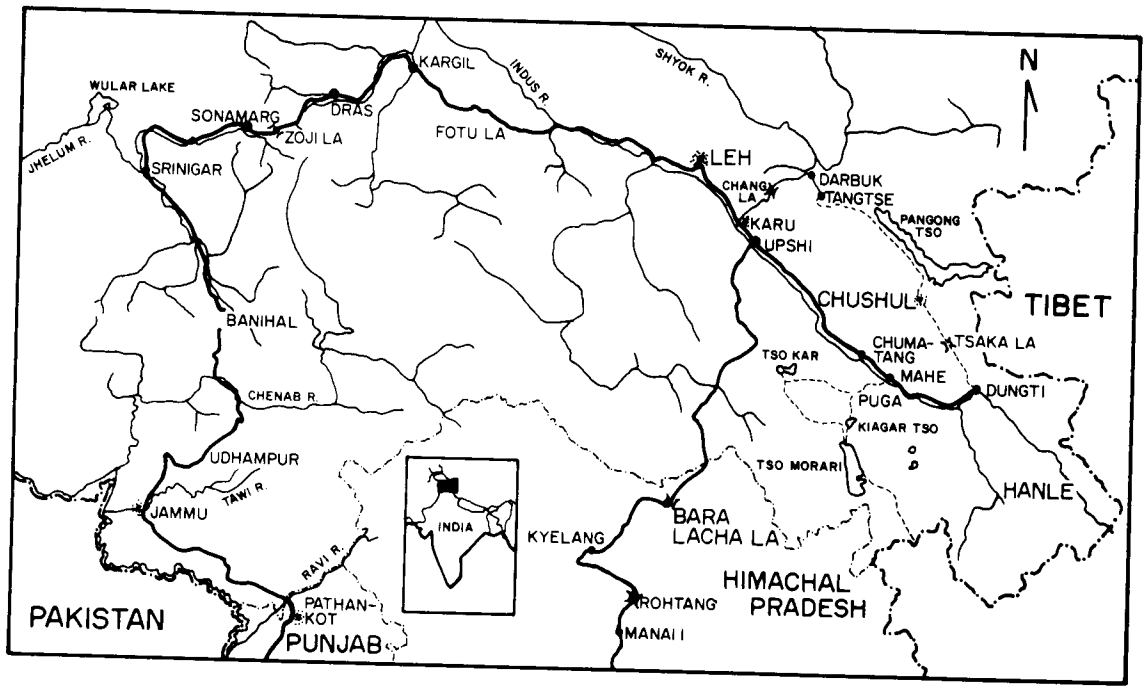


Fig. 1. Study areas in Ladakh.

thickets. Here and there I even saw a fresh-looking painted lady butterfly and grass that had started growing anew. But high-altitude birds like Guldenstadt's redstart (*Phoenicurus erythrogaster*) and robin accentor (*Prunella rubeculoides*) were still to be seen around Leh. We were certain that they would follow us to their breeding places at higher altitudes.

REPORT OF THE CRANES' ARRIVAL

The first objective was Hanle, the southernmost point on our itinerary, where a pair with a chick was observed in July 1976. On the way to Hanle the first authentic report of the arrival of cranes in Ladakh was received. Photographs had been used to elicit information from local people regarding the whereabouts of the cranes. When an army officer stationed in the area saw a photograph he immediately reported that he had seen a pair on 18 April and 1 May, on the banks of the Indus near Dungti. Later during a visit to the place we saw large toe-prints in the mud on the river bank. The print measurements were: middle toe--8 cm, outer toe--7 cm, inner toe--6 cm, and hind toe--3 cm. We believe the footprint was made by the Tibetan (black-necked) crane (Fig. 2).

SEARCH IN HANLE

Hanle: Latitude 32°47', longitude 79°4', elevation 4,340 m. The plain of Hanle is one of the principal plains in Ladakh. This 9.6- to 12.8-km-wide plain is overlooked by an impressive Buddhist monastery build on a hill. The tiny village of Hanle nestles below the hill. Several small streams meander across the plain. The ground surface is saline, where not swampy, and it is covered with coarse grasses. It is also very uneven and covered with little knolls encrusted with soda, some of them even floating in the marsh. Here and there are little puddles of brackish water. In early May their surface was covered with a thin film of ice. Hanle was reached on 5 May and a pair of the black-necked cranes was located the same evening. They were seen feeding in the southern portion of the grassy plain about 2 km from camp. They were not far from the hut of a shepherd and the route to the village to the west passed near where the cranes were 1st seen.

The local people said that the pair had been in the same location for about a week. The cranes had not been seen building a nest, although we were told a pair nested in the marsh in 1977. For the next 2 days we observed this pair in the field from 0800 to 1600 hours and followed their movements. In the early



Fig. 2. The black-necked crane.

morning the pair was observed in toe-deep water. They would then gradually walk towards the north feeding, intermittently. On the 1st day they flew north about 1030 and returned to the southern area at 1345 and began feeding again. The next day they flew north at 0800 and returned by 1320 to their favorite feeding spot.

Normally 1 looked around while the other fed. At times, if there was no movement of men and animals around, both would feed with their heads down. The male, who was a little taller than the female, stood behind his mate. Sometimes the female would walk a few paces away, then return to join the male after a few minutes. Sometimes the male would lead, the female following a little behind. Occasionally they shook their bodies, fluffed their feathers, and flapped their wings. They would often preen their abdominal and breast feathers and would polish the feathers of the throat and back with their beaks. They fed by probing with their bills in the mud and plucking aquatic vegetation. They would probe quickly 2 or 3 times and then swallow.

When we examined the puddle and sifted the mud where they fed, we found that the puddle mainly contained a species of coarse grass, the same that was found all over. We did not find tubers. The cranes also fed in the freshwater streams running through the plain. The streams were examined and contained a species of carp, some mollusca, a species of algae (*Nostoc*), submerged aquatic vegetation (mainly *Hydrilla* species), and some moss. We believe that the cranes fed mainly on grass; several times they were seen drinking water from the freshwater stream. Generally they were silent and only once uttered a short alarm call followed by a few meters of flight to escape from the path of a local villager who was crossing the marsh. I managed to get within 20 m of the cranes. We had put on Ladakhi clothing so our presence did not alarm the cranes. Once when I tried to get closer, the male uttered a throaty croak, croak, and moved about a meter farther away. On another occasion we heard their trumpeting call when they flew in from the north. They descended calling once, facing the wind, and executing beautiful turns.

We saw them indulge in a brief courtship dance only once. After they flew in from the north and alighted the male suddenly began waving his long neck up and down and tiptoed 3 or 4 paces ahead, turned, and spreading his wings came dancing back, still waving his neck, to face the female. He uttered a short soft call as he began his display. When the male came nearer the female responded by a similar up and down motion of her neck. The male then turned again to stand beside his mate, still waving his neck ceremoniously. The female, however, did not respond this time but stood still. They resumed feeding after some seconds. After observing their behavior I believed that the pair probably was not yet fully physiologically ready for nesting. We could not locate cranes in other marshes so we returned to Hanle on 23 May, hopeful that the pair would be in full breeding condition and might be seen building their nest. The pair, however, could not be located, even after a thorough search of the Hanle plain. We were told by the local people that the birds had not been seen for over a week.

MEADOWS OF THE PURPLE MOUNTAIN

Extensive meadows on the left bank of the Hanle River and to the north of Hanle village, were another area where presence of the crane was reported to us.

It was also reported that a pair nested there in 1976. But the place that was shown to us as the nest site appeared to be a most unlikely 1 for such shy birds to build a nest. It was very near a village path and afforded no protection to eggs or the incubating parents. Cranes were not seen but we believe that these meadows might be a foraging site for cranes. Grass and fresh water was abundant. Cranes that were known to fly north from Hanle might have visited this place for feeding and been seen by the local villagers. These meadows might be also used as a stopover place by the cranes while migrating in from the south along the Indus River and then along the Hanle River.

CHUMAR

Chumar lies about 50 km west of Hanle. We did not visit Chumar because we were told by officers, who had visited the area many times, that it was very dry and without marshes or meadows. To reach Chumar 1 has to cross Lanak La, a pass over 5,486 m high. We did climb to the top of this pass to look at the country beyond. The region was very rocky and sandy and contained 1 small, landlocked lake without surrounding vegetation. Cranes probably are wide-ranging in search of food and nesting places and might visit Chumar but the region could hardly provide nesting habitat for these birds.

TSO KAR NEAR DUNGTI

Tso Kar is another place we examined from a distance. South of Dungti about 34 km lies a belt of caragana. This area on the right bank of the Indus is a vast sandy plain containing 3 or 4 lakes. Throughout this vast area grows caragana and a short variety of grass, especially around the brackish lakes. Numerous flocks of sheep graze in this area. Only the lake nearest the Indus River is said to be within the borders of India. We were advised against going deeper into the area and exposing ourselves to unpredictable risks. The lack of means of crossing the swollen Indus River, however, prevented us from visiting even the nearest lake.

We had to be content with surveying the area from a hilltop by use of a telescope and binoculars. The area evidently lacked any freshwater streams and, except for a few brahminy ducks, no birdlife was detected. There are no islands in the lake where cranes could nest safely; neither are there any marshes. However, the area must be serving as a feeding place; that would explain reports of cranes seen in the area. After surveying this region bounded by the Indus and Hanle Rivers it appeared that these must be used by the birds as their migration route to come into Ladakh and to travel farther north. Cranes coming from the southeast may be traveling north to Chushul crossing over the Tsaka La (4,724 m). Other birds like grey heron (*Ardea cinerea*), goshawk (*Accipiter gentilis*), garganey teal (*Anas querquedula*), red-crested pochards (*Netta rufina*), little stints (*Calidris minuta*), and common and green sandpipers (*Tringa hypoleucos*; *T. ochropus*) were also noted and were presumably migrating northward.

TSO MORIRI AND TSO KAR BASINS

In the 1930's, 2 British observers saw the black-necked crane near these 2 high-altitude lakes. However, cranes were not seen during the 1976 survey. Tso Moriri, at an elevation of 4,541 m, is 25.6 km long and 3.2 km wide. When the lake was visited on 15 May it was still partially frozen, only a small portion (about 4.8 km long) being open water. Although

no cranes were seen, 42 bar-headed geese were present. There is a small island in the lake about 1.6 km from the north bank on which the geese nest. The number of geese observed was the same as observed in 1976. Apparently the full complement of geese had arrived on their breeding ground. However, we did not observe any pair trying to construct a nest (15-17 May).

About 48 km northwest of Tso Moriri lies the salt lake Tso Kar. Vast belts of soda surround it but it is fed from the west by a freshwater lake called Startsapuk Tso. Weed masses float on the surface of Startsapuk Tso, an ideal refuge for nesting birds. On these floating islands nest about 400 brown-headed gulls (*Larus brunnicephalus*), some bar-headed geese, and great crested grebes (*Podiceps cristatus*). When we reached Startsapuk Tso we found that the gulls had already arrived and were assembling on the floating islands but none had laid eggs. Neither the great crested grebes nor the bar-headed geese had started nesting. The numbers of geese were considerably smaller than the population found in 1976. We saw no cranes there.

MARSH NEAR THUGJE GOMPA

This was the only place where more than 1 crane pair had been reported. The local populace reported that cranes had been there in 1977. The marsh was similar though more alkaline than the marsh at Hanle; however, it was smaller and could not support many cranes. In the vast alkaline flats around the Tso Kar we found 250 to 300 ruddy sheld ducks (*Tadorna ferruginea*).

MARSHES AROUND CHUSHUL

By the time we reached Chushul we had become quite pessimistic about finding a nesting crane pair in Ladakh. On the way to Chushul we also received a report from the local forest ranger that the pair nesting there had been killed in 1977. Chushul (latitude 34°35', longitude 78°43', elevation 4,328 m) is 16 km south of Pangong Lake in the corner of a vast sandy plain in which are scattered freshwater streams, brackish pools, extensive belts of caragana, and beds of salt. There is also a smaller plain to the west of Chushul. A freshwater lake surrounded by a broad stretch of marshland lies in this plain. The lake holds some tiny islands and in 1976 a clutch of 2 crane eggs was collected from a nest on 1 of the islands. Ducks and geese come to the lake in summer and the lake, as well as the stream that feeds it, contains many fish. The plain to the east has little fresh water and is more alkaline. In 1976 a solitary crane was seen in this area.

After reaching Chushul, the lake and marsh west of the village were searched but cranes were not seen. When we started searching the vast eastern plain we had already given up hope of ever finding cranes in that area. Imagine our surprise when 1 evening through our binoculars we saw 2 slender blacknecks far away. The crane pair was seen foraging near a flock of sheep in a salt-encrusted marsh. They were extremely wary and did not allow us to come within 150 m even though we were wearing Ladakhi clothing. They engaged in a short courtship display; the male with outstretched wings danced around the female and with a short run tried to lead her. But when we attempted to get closer the pair gave a short alarm call and flew to the north. They alighted about 3 km away in a freshwater marsh enclosed by high sand dunes that completely hid the marsh from the surrounding plain. They fed quietly in the marsh but once emitted a

bugle-like call (unison call?) stretching their necks and pointing their bills skyward. Both of them spread out their wings when they called. In this little freshwater marsh hidden from the main plain we found the nest of the black-necked crane.

The nest was in a shallow marshy pool in which grew an aquatic plant believed to be *Hydrilla*. The nest was about 30 m from the banks and could not be reached without wading through 0.3-m-deep water. The nest was a platform of aquatic vegetation plucked from the surrounding pool. The platform was about 25 cm high, 1.5 m long, and 0.6 m wide, made entirely of *Hydrilla* sp. (local name Zema).

When the nest was discovered on 26 May we found 2 eggs. The eggs appeared to be fresh and must have been laid in the previous 2 or 3 days, because in the next 2 days they became quite soiled as the cranes turned them with their wet feet. The shells were creamy with brown spots. On 25 May the crane pair was about 3 km from the nest. The eggs were unattended for more than 2 hours. It is surprising that during the time the eggs were not destroyed by predators. The requirements for a nest site seem to be marshland with a pool of fresh water, an island, or a place not accessible to predators, and meadows nearby for foraging.

For the next 3 days the cranes were watched intensively from a blind that was gradually moved closer until it was on the edge of the pool. Both birds incubated the eggs. They shared almost equally in incubation duties. The nest and the incubating pair were observed for 24 hours; the female incubated 10 hours and 15 minutes, the male for 9 hours and 50 minutes, and the nest was unattended for almost 4 hours. The incubating bird often rose to leave the nest at the slightest disturbance, even if a man appeared some 150 m away. After a bird left the nest in this manner it would not return but its mate would come forward and settle on the eggs. Sometimes the exchange was quite quick, the incubating bird leaving the eggs 15-20 minutes after starting and his mate, who had perhaps sat on the eggs for more than an hour, was obliged to come back to the nest. The birds were not observed adding any nesting material to the nest.

The changeover was not accompanied by ceremony. Normally the male or the female would incubate eggs for a period of 1 to 1.5 hours. The mate, which had been feeding at the edge of the pool, would slowly approach the incubating bird from behind and climb on to the nest. The sitting bird would then stand and both would start rearranging the nesting material. The incoming bird would take up its position, while rearranging nesting material. As the arriving crane sat down it shuffled the eggs into position. The departing mate stood with its tail over the head of the sitting bird and continued rearranging material while slowly descending the nest platform. It would then flap its wings, as if to shake off lethargy, and slowly move to the edge of the pool.

Usually the nesting pair was extremely silent. Only once when their nest was approached for closer examination and photography did the incubating bird utter a short alarm call. It appeared that they were taking every precaution to avoid drawing attention to their nest by such actions as emitting a call, hasty movements, and flight.

The eggs remained unattended quite often, sometimes for long periods. When the nest was discovered the incubating bird moved away. It took 3 hours for 1

crane to return to the nest and continue incubating. Subsequently, whenever the incubating bird feared disturbance it would leave the nest and the bird's mate might not return to the nest for 25 minutes. As evening approached the birds would not leave the eggs for as long. Late evening observations showed that a crane returned to incubate within 5 minutes.

The night watch revealed that the incubating bird would sit on eggs for longer periods and the other would rest within 3 m of the nest, standing often on 1 leg for as long as 50 minutes. Any changeover at night could not be observed because the weather was very cloudy and until the moon rose around 0300 hours it was very difficult to observe any activity around the nest. Once or twice early in the morning (around 0430) the incubating bird stood up, stretched its legs, and sat down again. At dawn we could discern that the male was incubating. At daylight we saw him rise and join his mate who was standing about 30 m away. They stood together for about 10 minutes preening their feathers. The female bird then slowly came forward and sat on the nest. This time the nest remained unattended for 20 minutes.

The incubating bird normally sat facing the sun, with his bill resting on his chest, and the nape touching the back. But often he would extend his neck looking in all directions, presumably taking stock of the situation.

While feeding, the birds would often splash water with sideways sweeps of their beaks, as if they wanted to wipe off mud stuck to their beaks. Sometimes they would immerse their heads in the water and splash water on their own body, as if they were washing.

Even if the eggs remained unattended for as much as half an hour, no predatory birds were seen to disturb the eggs. In fact, in the nesting area we never saw a predatory bird like a raven (*Corvus corax*). A pair of brown-headed gulls and 3 pairs of common terns (*Sterna hirundo*) appeared to be residents of this marsh.

Normally the gulls and terns remained quite indifferent to the nest and the pair. Only once was the gull observed to swoop down on the incubating crane who ducked to avoid its attack. On another occasion when the birds had left the nest a pair of common terns landed on the nest platform but they did no damage. Three pairs of ruddy sheld ducks were also usually feeding nearby. They were extremely wary and raised an alarm cry at the slightest disturbance. In a way they helped the breeding pair by warning them of danger. In fact the cranes would return and sit on the nest when they saw the brahminy ducks return to their feeding ground and start feeding again.

MARSH NEAR HOWRANG

This area, visited on the way from Chushul to Leh, is an extensive meadowland, a freshwater stream, and a small pool. We found no cranes. Unfortunately we could not converse with the locals who were grazing their sheep and cattle in the meadows and, therefore, could not determine anything about the past occurrence of the black-necked crane there. We returned to Leh on 31 May after spending 28 days in the field. During this survey we had logged more than 1,700 km by jeep, about 50 km on ponies, and many more on foot.

CONCLUSION

From our investigations, and inquiries made with various local people in Ladakh, it appears that not

more than 4 crane pairs visited Ladakh in summer 1978. Flocks of cranes in early spring were not reported to us from any location. It appears that not more than 3 pairs have been nesting in Ladakh. The most probable nesting places are the marshes near Hanle and Chushul. The vast sandy plain, covered with caragana, north and south of Dungti is another probable area that should be investigated thoroughly. But this area lies very close to the border and free movement in it may be politically inexpedient.

Compared with the conditions in 1976 it appears that the movement of animals and people has increased in all the above probable breeding areas. It was also reported that a crane pair was killed in 1 of the areas mentioned. The cranes apparently have abandoned some of their traditional nesting areas and have moved to places where such disturbances are likely to be minimum.

Even in early spring, when snows had not melted, we found few wildlife at lower elevations of 4,267 to 4,877 m. We were told that wildlife had moved to remoter areas and that their numbers had not declined. However, on closer questioning, people who had seen wild animals could report coming across only single individuals or a pair or a flock of 5 to 7 animals. We believe that wildlife of the region has become scarce because of increased pressure on their habitat from humans and domestic animals. The presence of army posts and personnel, even in remote and high places, cannot be denied. Places free of human movement are very few. The wildlife of this area deserves all the protection they can get.

Compared with 1976 the number of bar-headed geese in the area appears to have declined considerably. In 1976 we counted more than 100 geese on their traditional breeding areas. This time we could hardly find 60. Besides crane, this goose is another bird that deserves utmost protection.

The number of bird species observed in the field was 90 (Table 1). Birds like spotless starling (*Sturnus unicolor*) and rose-colored starling (*S. roseus*) were, to our knowledge, recorded in this area for the first time. Some migrant birds were recorded near Dungti on the Indus River. Compared with 1976 we recorded a greater variety of birds of prey. The blue rock thrush (*Monticola solitaria*), which normally nests around or below 3,000 m, was found nesting at 4,260 m. The hoopoe (*Upupa epops*) and the house sparrow were also recorded at elevations above 4,260 m.

RECOMMENDATIONS

No one will disagree that the black-necked crane should be completely protected. The problem is how to enforce complete protection. We believe the following steps will go a long way towards ensuring greater protection for the cranes:

1. Because of its rarity the bird is unknown to most of the army and other personnel stationed in the area. Even among Ladakhis, except for a few shepherds and Tibetan refugees who travelled in the high-altitude areas, very few have seen a crane. I therefore recommend that a large colorful poster depicting the crane pair should be produced and distributed throughout the area. It should contain an appeal to give protection to the bird.
2. There was already talk of adopting this bird as a symbol of Ladakh. We commend this move. The crane should be officially adopted as the national

symbol and the proposal should be given wide publicity through the news media. The army can also adopt the bird as their mascot and contribute to its protection.

3. The marshes around Hanle and Chushul should be declared sanctuaries. The movement of shepherds and flocks should be restricted in these areas, but we do not recommend exclusion of such movements. We have noted that the presence of sheep and their Ladakhi herders offer the birds some protection, because Ladakhis consider the bird sacred and do not kill it. Too much human movement, however, seems to disturb a pair, especially when they are nesting. This disturbance can be avoided.
4. The Forest Department should consider whether guards can be posted from April to July in Chushul and Hanle to watch and protect crane pairs. Department personnel should be required to gather information on the movement of the pairs and report on actual nesting sites. The location of nesting sites should be kept secret.

With so low a population of breeding crane pairs in Ladakh, initiating a program of collecting eggs for captive breeding seems difficult. Better protection should allow the number of breeding pairs to increase. After a few years the situation can be reviewed.

Dr. Salim Ali has already recommended creation of a national park and wildlife reserves in the area. This proposal should be actively considered and translated into practice. The army and other agencies functioning in the area should be actively involved in any wildlife conservation program. Appointment of honorary wildlife wardens should be considered.

The feasibility of initiating a game-ranching program at suitable places in Ladakh should be examined. It would be better if the army were associated with the game ranch, particularly because a nucleus of captive animals already exists in the zoo in Leh. The zoo then can not only be expanded and modernized but will also become more meaningful to the troops and officers caring for the animals.

ACKNOWLEDGMENTS

I wish to acknowledge with gratitude the help given by the following agencies and individuals: Mr. S. S. Rizvi, Development Commissioner, Leh, who arranged for the permission for our movement in the Inner Line Area. Without his kind support to our efforts it would have been very difficult to establish liaison with our governmental agencies. Gen. Somanna, GOC, Leh, very kindly arranged for our movement within the Inner Line Area and provided every kind of assistance to make our camping and field trips comfortable. Mr. Shahniaz Naqashbandi, Divisional Forest Officer, Leh, kindly made arrangements through his staff who helped us in tracking, establishing friendly relations with local people, and looking after us whenever we camped out. Mr. Deshpal, Game Ranger, Leh, also helped us in establishing contacts with local people and procuring items of food and equipment for the expedition. Wherever we went we were most cordially received by the officers and men of the Indian Army and also by officers of other agencies working in this area, e.g., the Indo-Tibetan Border Force, stationed at Leh and Kargil, especially by Lt. Col. Y. P. Singh. Mr. A. R. Wani, Special Secretary, Tourism Department and Honorable Representative of World Wildlife, India in Srinagar, kindly looked after our conveniences and helped us in many ways.

Table 1. Bird species seen in Ladakh, 1978.

Common name	Latin name	Common name	Latin name
Great crested grebe	<u>Podiceps cristatus</u>	Crag martin	<u>Hirundo rupestris</u>
Grey heron	<u>Ardea cinerea</u>	Barn swallow	<u>H. rustica</u>
Bar-headed goose	<u>Anser indicus</u>	House martin	<u>Delichon urbica</u>
Ruddy shield duck	<u>Tadorna ferruginea</u>	Yellow wagtail	<u>Motacilla flava</u>
Garganey	<u>Anas querquedula</u>	Yellow-headed wagtail	<u>M. citreola</u>
Red-crested pochard	<u>Netta rufina</u>	Grey wagtail	<u>M. cinerea</u>
White-eyed pochard	<u>Aythya nyroca</u>	Hodgson's pied wagtail	<u>M. alba alboides</u>
Tufted duck	<u>A. fuligula</u>	Streak-eyed wagtail	<u>M. a. ocellalis</u>
Black-eared kite	<u>Milvus migrans</u>	Tree pipit	<u>Antus trivialis</u>
Pallas' fishing eagle	<u>Haliaeetus leucoryphus</u>	Water pipit	<u>A. spinoletta</u>
Goshawk	<u>Accipiter gentilis</u>	White-breasted dipper	<u>Cinclus cinclus</u>
Long-legged buzzard	<u>Buteo rufinus</u>	Robin accentor	<u>Prunella rubeculoides</u>
Rough-legged buzzard	<u>B. lagops</u>	Brown accentor	<u>P. fulvescens</u>
Golden eagle	<u>Aquila chrysaetos</u>	Siberian rubythroat	<u>Luscinia callope</u>
Bearded vulture	<u>Gypaetus barbatus</u>	Bluethroat	<u>L. svecica</u>
Black vulture	<u>Aegypius monachus</u>	Common redstart	<u>Phoenicurus phoenicurus</u>
Saker falcon	<u>Falco cherrug</u>	Guldenstadt's redstart	<u>P. erythrogaster</u>
Hobby	<u>F. subbuteo</u>	Hodgson's stonechat	<u>Saxicola insignis</u>
Kestrel	<u>F. tinnunculus</u>	Pied wheatear	<u>Oenanthe pleschanka</u>
Tibetan snowcock	<u>Tetraogallus tibetanus</u>	Desert wheatear	<u>O. deserti</u>
Chukar partridge	<u>Alectoris chukar</u>	White-capped water redstart	<u>Chaimarrornis leucocephalus</u>
Tibetan partridge	<u>Perdix hodgsoniae</u>	Blue rock thrush	<u>Monticola solitaria</u>

Black-necked crane	<u>Grus nigricollis</u>	Tickell's thrush	<u>Turdus unicolor</u>
Coot	<u>Fulica atra</u>	Lesser whitethroat	<u>Sylvia curruca</u>
Mongolian plover	<u>Charadrius mongolus</u>	Chiffchaff	<u>Phylloscopus collybita</u>
Little stint	<u>Calidris minuta</u>	Willow warbler	<u>P. trochilus</u>
Temminck's stint	<u>C. temminckii</u>	Grey tit	<u>Parus afer</u>
Redshank	<u>Tringa totanus</u>	Rock bunting	<u>Emberiza cia</u>
Green sandpiper	<u>T. ochropus</u>	Goldfinch	<u>Carduelis carduelis</u>
Common sandpiper	<u>T. hypoleucos</u>	Twite	<u>Acanthis flavirostris</u>
Common snipe	<u>Gallinago gallinago</u>	Hodgson's rosy finch	<u>Leucosticte nemoricola</u>
Brown-headed gull	<u>Larus brunnicephalus</u>	Great rosefinch	<u>Carpodacus rubicilla</u>
Common tern	<u>Sterna hirundo</u>	Gold-headed finch	<u>Pyrrhoplectes epauletta</u>
Rock dove	<u>Columba livia</u>	House sparrow	<u>Passer domesticus</u>
Blue hill pigeon	<u>C. rupestris</u>	Adams' snow finch	<u>Montifringilla adamsi</u>
Rufous turtle dove	<u>Streptopelia orientalis</u>	Red-necked snow finch	<u>M. ruficollis</u>
Eagle owl	<u>Bubo bubo</u>	Blanford's snow finch	<u>M. blanfordi</u>
Common swift	<u>Apus apus</u>	Rose-colored starling	<u>Sturnus roseus</u>
Hoopoe	<u>Upupa epops</u>	Spotless starling	<u>S. unicolor</u>
Eastern calandra lark	<u>Melanocorypha bimaculata</u>	Golden oriole	<u>Oriolus oriolus</u>
Calandra lark	<u>M. calandra</u>	Magpie	<u>Pica pica</u>
Short-toed lark	<u>Calandrella cinerea</u>	Red-billed chough	<u>Pyrrhocorax pyrrhacorax</u>
Skylark	<u>Alauda aevensis</u>	Yellow-billed chough	<u>P. graculus</u>
Horned lark	<u>Eremophila alpestris</u>	Carrion crow	<u>Corvus corone</u>
Sand martin	<u>Riparia riparia</u>	Raven	<u>C. corax</u>

CONSERVATION NEEDS OF BLACK-NECKED CRANES OF BHUTAN, ARUNACHAL PRADESH, AND LADAKH

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Abstract: The black-necked crane (*Grus nigricollis*) is the least known of the 14 species of crane in the world. The survey was to determine its status as a winter visitor in Bhutan and Arunachal Pradesh and to locate and observe cranes nesting in Ladakh. The occurrence of the species in Bhutan has been confirmed. An important roosting bog has been identified and Bhutan authorities have been requested to protect it. The cranes are fully protected in Bhutan and are somewhat tame. Any danger to their continued occurrence there stems from habitat destruction. The flock in Arunachal Pradesh has stopped wintering in the Apa Tani Valley because of killing by natives who now possess firearms. Small wintering flocks probably still visit more remote valleys and wetlands in Arunachal Pradesh. The Tawang Valley in the Kameng Division of Arunachal Pradesh is unsuitable for cranes through the marsh south of Seppa in the western part of the Division. The cranes in Ladakh were again seen at Hanle and Chusul. The Chusul pair had laid, but the eggs were presumably lost to predators. This loss precluded an in-depth study by the principal investigator. A crane pair was found on a marsh at the southern extremity of Tso Morari, and more nesting areas of bar-headed geese (*Anser indicus*) and ruddy sheld ducks (*Tadorna ferruginea*) were located at Karzok Gumpa and on the southern end of the lake. Tso Morari is, therefore, the largest and perhaps the most important water bird breeding lake in Ladakh. Further in-depth studies on the cranes in Bhutan and at Chusul are recommended with the objective of setting up protected areas. Fullest involvement of the Ladakh Armed Forces is recommended to ensure the security of the nesting cranes. Recommendations are made to protect crane bogs in Bhutan. Crane eggs should be collected from Chusul and Hanle and a pair of adult cranes be captured from Boomthang if the International Waterfowl Research Bureau (IWRB) approves this action. The survey has produced color photographs of the black-necked cranes from Bhutan and Ladakh. A clearer idea has been gained of the possibilities and problems of in-depth studies on specific inquiries, and the immediate conservation needs are better understood.

Among the 5 species of crane the black-necked or Tibetan crane remains the least known and there have been no prolonged observations of the species. A paper prepared by George Archibald and Marie Oesting (this proceedings), although being exhaustive in accumulating all known data through 1974, merely highlights the fact that information is fragmentary. The present survey in Bhutan, Arunachal Pradesh, and Ladakh, therefore, was aimed at gaining more information on this crane within India.

METHODS

In January and February 1978, I visited Central Bhutan and the Apa Tani Valley in Arunachal Pradesh (Fig. 1, Appendices 1 and 2). The situation is further discussed to provide the basis for a continuing study of the cranes wintering there. This had been Phase 1 of the Project. In December 1979 and January 1980, I visited Sikkim and the Kameng Divisions of Arunachal Pradesh.

Phase 2 involved a visit to the Ladakh breeding areas (Fig. 1), wherein Prakash Gole went over the route followed by him with Dr. Salim Ali and the Bombay Natural History Society party in June 1976. In 1978, Prakash was in Ladakh from 24 April to 31 May. He has submitted a separate report on his findings (see this proceedings). When he located a pair of black-necked cranes with freshly laid eggs at Chusul, I followed up with the objective of studying the parents and, hopefully, their safely hatched chicks until August and then to continue on to the Rupshu Plateau to assess the other unvisited marshes south of Tso Morari, which I suspected might be suitable habitats for the cranes.

In this report, I discuss general conservation considerations for the black-necked cranes in India and provide updated information on the status of the species. Thus, this report deals with the broader aspect of conservation of the cranes' habitats rather than with the breeding biology of the black-necked crane.

In both the Eastern Himalayas and Ladakh the logistics of travel and spending time in the field still

remains difficult despite the many new roads into the interior. A field worker must either have his own vehicle and possess mechanical competence to ward off breakdowns in desert country or depend entirely on support by the military or paramilitary organizations operating in the advance areas. Despite availability of either arrangement which would help to place the field worker closer to his area of work, he will still have to rely very heavily on traditional modes of transport like porters or pack animals to get him to his work areas. The latter mode of progress, though slower, is more dependable and provides for greater independence of operation. Any effective surveys in these areas have to take these factors into account.

Both in 1976, and after Prakash Gole's survey in 1978, certain recommendations have been made for Ladakh. I have kept these in mind while developing my recommendations. This report, therefore, although failing to throw more light on the breeding biology of the species, aims at providing a basic appreciation of its general conservation needs. A further visit to Chusul or Hanle has to be made to complete this aspect of the assignment. The major achievement of the survey has been the acquisition of several good color photographs of black-necked cranes in both Bhutan and Ladakh.

OBSERVATIONS IN BHUTAN

The survey has established that black-necked cranes winter in the Boomthang Valley of central Bhutan. A party from the Zoological Survey of India also reported having seen a small flock near Tashiyansi in eastern Bhutan. The latter area was on my itinerary but could not be visited because the road from Boomthang to Tashiyansi had been breached by heavy winter snow and rain in several of the higher passes. Besides these 2 locations, there are possibilities of flocks wintering in other valleys in Bhutan, particularly in those closer to the Tibetan border and having a dry, cold climate similar to that of Boomthang.

Observations made on the Boomthang flock reveal that the birds do not feed in flocks, but pairs and family groups scatter in the morning shortly after

dawn and again converge at dusk to roost on a secluded bog for the night. At Boomthang the importance of 1 particular bog for the birds' survival was noted and this information was conveyed to the authorities. We have received information that His Majesty's Government of Bhutan has issued orders to have the bog protected and the drainage activities stopped.

I also confirmed a favorable aspect for the species' survival, that the black-necked cranes during winter are not entirely aquatic in their habitat preference and feed in stubble fields, gleaning waste grain. They are, however, attracted to boggy areas which border the fields and certainly show a preference for them. In the bogs they dug up and fed on small round bulbs. The mud also contained large numbers of earthworms and hibernating frogs. There were plenty of black tadpoles actively swimming in the unfrozen flowing water. S. S. Saha of the Zoological Survey of India, Calcutta, who accompanied me, has made a collection of all specimens of animal life in the mud and of the bulbs.

The cranes feed in widely separated pairs and show a territorial tendency; any intrusion by another of the species results in threats by the owners. This territorial behavior was observed in a pair established near Baykar Dzong and a lone bird, which presumably had lost its mate and tried repeatedly to join them. Although the trio occupied a common meadow, the lone bird was usually seen at the farthest extremity from where the pair were feeding, often out of sight behind a raised road that dissected the meadow. On 1 occasion all 3 were together and it was possible to observe the interaction. One of the pair, presumably the male because of his larger size, crouched and diagonally approached the intruder which kept its distance by diagonally retreating while assuming a similar crouching posture. After a continual displacement for about 10 minutes the lone bird flew across the road. The victorious attacker raised himself to full height with the black hind plumes raised. This position was retained until the fugitive was out of sight and then he turned and rejoined his mate.

The pairs and family groups scatter from the roost at daybreak. Foraging continues until around 1030 hours, when the diurnal winds start to blow strongly. Feeding is greatly reduced and considerable preening occurs at about 1200 hours, when the winds are the strongest. One of the pair settles down among dry grass to sleep; at no time did both birds sleep together. Feeding was resumed at around 1500 hours. At 1700 hours, with the shadows lengthening, feeding stopped and both birds would vigorously start preening until shortly after sundown, when, without any prior indication, both would suddenly face the waning wind and take flight. I was close enough to hear 1 of the pair utter a subdued "cruck" before taking flight. The birds flew in the general direction of the roost.

All the pairs and family parties, presumably the entire Boomthang population, before flying to the roost bog (Fig. 2) for the night, landed in an open field some distance from the roost¹. There the adults

quietly stalked around or preened themselves while the juveniles pecked at each other. They tolerated local people; a man or woman returning home could walk right through the flock without causing any alarm. The birds in the person's path would move off to 1 side. After it had grown quite dark the entire flock would suddenly rise and fly directly to the roost. One evening the birds were not at the prerost landing area and I noticed there was considerable light from the new moon. The birds flew in well after 1830 hours and went directly to the roost. As they flew over, I heard very soft "crucks" of the adults and the chirruping of the juveniles in response. The single bird had flown to the roost at the usual time and on hearing the others coming, it loudly trumpeted; the others called back. There was considerable calling as the birds landed and the trumpets sounded very like those of the sarus crane (*G. antigone*).

From the birds observed in Bhutan I surmised that a larger number of pairs had failed to rear any chicks, and it seems that only very few apparently could raise 2 chicks. Thus, the mortality rate of young birds in Tibet must be very high, and this should be kept in mind when considering the collection of eggs from nesting birds to set up a captive breeding program (Appendix 1).

During January, the cranes in Bhutan were very quiet and undemonstrative towards each other. They however remained near each other at all times. Only once, and then very briefly, did 1 of the pair dance. Upon being disturbed by Saha and myself, the pair started to walk away. Suddenly the male turned around, opened his wings partially, and started pumping his neck as he approached the mate.

The birds were a little wary of us in different clothing, although they did not show the least alarm at the approach of local peasants going about their business or of domestic stock which freely grazed around the birds (Fig. 3). It was startling, however, how a pair which I had been photographing suddenly became alert, stood with necks stretched to full height on hearing a very distant and almost inaudible 0.22 rifle shot (Fig. 4). Soon after, they took flight. This suggests the birds have learned to associate rifle shots with danger and have, presumably, lost the immunity they had once enjoyed in their Tibetan summer habitat.

In Bhutanese, this crane is known as the Thung Thung, a variation of the Tibetan Trung Trung. It is a well-known bird to the people of the Boomthang Valley and the nearby Gaysta Valley. They speak of the cranes collecting in the open meadow below Baykar Dzong in March and performing communal dances. These dances, I was told, are initiated even if a passing man waves his arms at the birds. Soon after the birds are said to leave for Tibet.

There are very authentic representations of the Trung Trung in the colorful "Thankas" or religious wall hangings in the chapel of the Baykar Dzong.

ARUNACHAL PRADESH

The only known wintering area of black-necked cranes south of the Himalayas was the Apa Tani Valley in Arunachal Pradesh, then known as the North East Frontier Agency (NEFA), until 6 were sighted near Tashiyangsi in eastern Bhutan by the team of the Zoological Survey of India, and the subsequent reports of the cranes visiting Boomthang in central Bhutan. The

¹Among sandhill crane (*G. canadensis*) similar behavior is sometimes observed. Robert Wheeler termed these fields "secondary roosts." They were wet meadows or pastures where the cranes congregated before roosting in evening and after roosting in early morning. See also Kawamura article in this Proceedings (Editors' note).

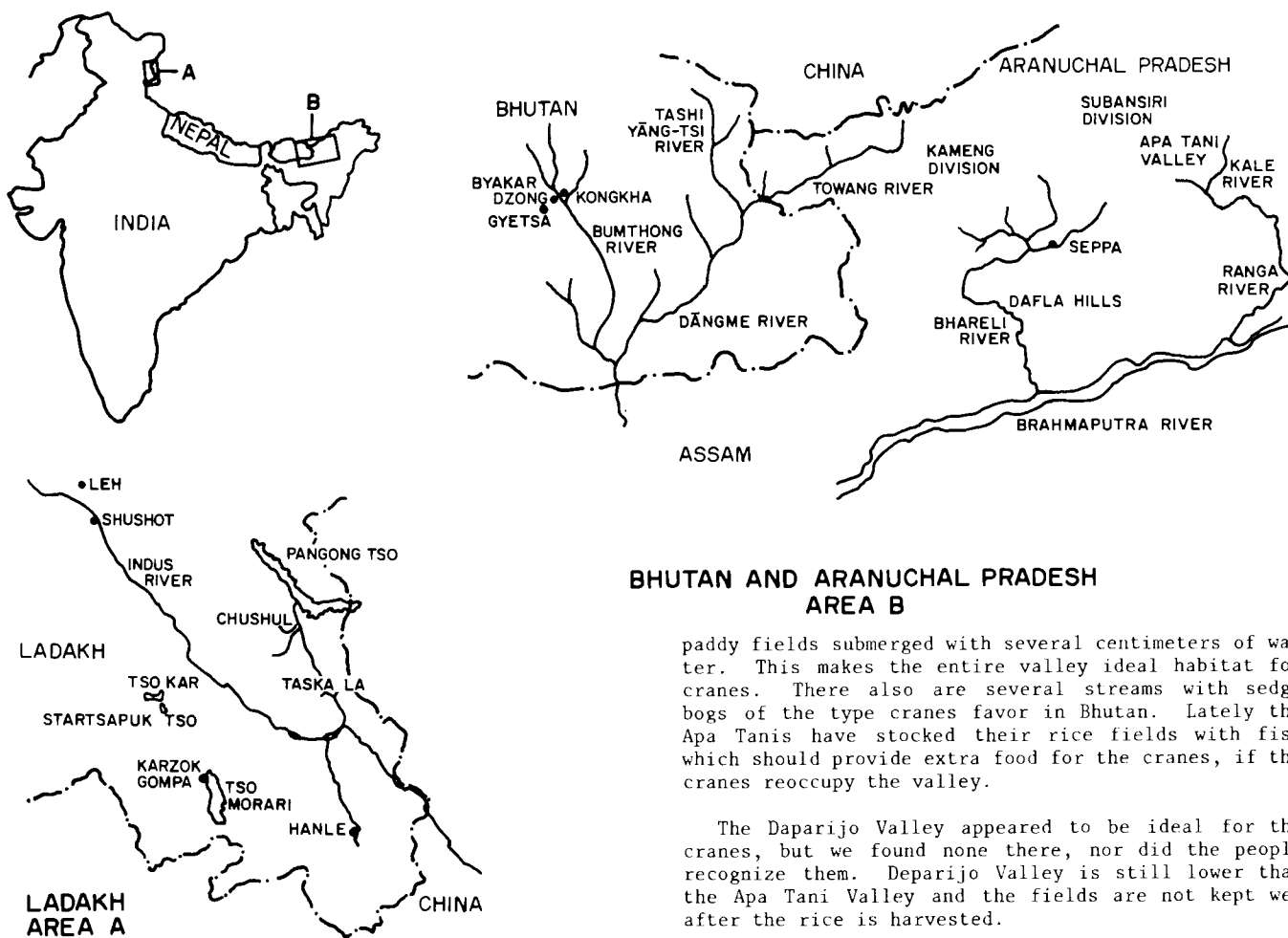


Fig. 1. The field survey areas (upper left) in Ladakh (Area A), Bhutan, and Arunachal Pradesh (Area B).

latter flock of about 30 birds was reported by Col. F. N. Betts in the Journal of the Bombay Natural History Society in 1955. He mentioned that the birds were unmolested by the Apa Tani tribals. During my survey with Shri S. S. Bhatti, Chief Wildlife Warden of Arunachal Pradesh and S. S. Saha of the Zoological Survey of India, we failed to find any birds there.

We were told by villagers that the cranes used to be regular visitors a decade ago, but that they had stopped coming because the Apa Tanis, who now possess firearms, hunted them. The last pair to winter in the Valley was killed and eaten 2 years previous. The Apa Tanis call these cranes "Kengda."

The Apa Tani Valley is a little above 1,830 m elevation, much lower than Boomthang Valley. It enjoys a more temperate climate which is moister and warmer than the crane's habitats in Bhutan. To reach the valley, the cranes have to fly across thickly wooded mountains and valleys. Thus, there are likely other flocks wintering in other valleys of Arunachal Pradesh where suitable conditions prevail. The areas worth examining are the lowland marshes in Lohit Division and the marsh south of Seppa in western Kameng Division. The Tawang Valley of the Kameng Division has no area suitable for cranes.

The Apa Tani Valley is intensively cultivated (Appendix 2). The tribals, however, keep the harvested

paddy fields submerged with several centimeters of water. This makes the entire valley ideal habitat for cranes. There also are several streams with sedge bogs of the type cranes favor in Bhutan. Lately the Apa Tanis have stocked their rice fields with fish which should provide extra food for the cranes, if the cranes reoccupy the valley.

The Daparijo Valley appeared to be ideal for the cranes, but we found none there, nor did the people recognize them. Daparijo Valley is still lower than the Apa Tani Valley and the fields are not kept wet after the rice is harvested.

LADAKH

The 1976 expedition led by Dr. Salim Ali confirmed nesting of black-necked cranes in locations first mentioned by earlier ornithologists, e.g., Osmaston and Meinertzhagan. Coinvestigator Prakash Gole was a member of this expedition. A pair was seen at Chusul where the observers were told that an egg had been collected earlier from a nest in a small freshwater lake west of Chusul. At Hanle they found a 2-week-old chick and saw the parents. Expedition members were also told that a pair had been shot near the Indus by a member of the paramilitary forces.

In 1978, Phase 2 of this survey had as its objectives (1) a resurvey of all the breeding marshes covered in 1976, in the middle of April and May, to locate pairs of cranes shortly after their arrival for the summer; (2) to locate nests with freshly laid eggs for subsequent observation; and (3) to try to collect 1 egg from each of the nests for transfer to Leh and subsequently to International Crane Foundation in the United States of America to establish a captive breeding flock. Prakash Gole, accompanied by Ingalhalikar, saw and photographed a pair at Hanle and located a nest with 2 freshly laid eggs in a small lake east of Chusul. Unfortunately, Gole was unable to stay and watch the nest until I arrived the last week of June.

Before leaving, Gole made arrangements through the forest department to have a villager from Chusul observe the breeding pair. The villager did not watch them and I discovered the birds had lost the eggs to some predator. My opinion is that the eggs were taken

by 1 of the many Tibetan ravens (Corvus corax) which live around Chusul. The only other predators inimical to the cranes at Chusul are foxes and man. Both the latter can be safely ruled out, the 1st because of the deep water around the nest, and the 2nd because the local people do not harm the cranes and the military and paramilitary personnel were all aware of the official interest in the well-being of the particular pair. Gole had noted the incubating bird would leave the nest at the approach of a passing human being or larger domestic animals. I found large numbers of ponies, yaks, and flocks of goats and sheep grazing on the lush turf around the lake. Yak waded into the water to feed on aquatic vegetation and, thereby, disturb the bird on the nest (Fig. 5).

After a careful 2-day search the pair was found in a shallow brackish marsh a couple of kilometers away. They were observed for 2 more days to confirm they had no chicks with them. The pair was extremely wary and did not permit a close approach, in marked contrast to the cranes in Bhutan, and those I had seen in south-western Tibet in 1954.

The cranes seemed to be feeding on very minute matter in the water. They never submerged their bills, but seemed to pick all the food from near its surface. They were not seen digging in the mud as had occurred in Bhutan. I believe this pair was mainly feeding on the huge shoals of shrimp-like larvae which teemed in all the freshwater and brackish pools. They might have also picked up aquatic plants, but I could not confirm this. All the freshwater streams in Ladakh had plenty of fish which were not difficult to capture by hand and these must also form a considerable part of the crane's diet. Incidentally, the common tern (Sterna hirundo) is a common wetland bird feeding on these fish and the larvae referred to form an important diet for the great-crested grebes (Podiceps cristatus) which breed, often in considerable numbers, on Tibetan lakes.

Perhaps because of their having lost their eggs, the Chusul pair were very undemonstrative to each other and their feeding and preening in intervals seemed very desultory. Also, I did not hear them calling.

Subsequently I surveyed the Tso Kar depression and examined Tso Kar, the nearby Startsaphuk Tso and the Thukje Marsh, but found no cranes. There were many ruddy sheld duck with small ducklings there and at Chusul, great-crested grebes with chicks, and brown-headed gulls (Larus brunnicephalus) with fully fledged young.



Fig. 2. View down Boomthang Valley from Baykar Dzong. The arrow indicates the roosting bog.

Both the 1976 expedition and Gole in 1978 had examined the northern end of Tso Morari. I approached the lake from the west and surveyed the entire lake along its west and south shores. I located 2 large breeding areas of bar-headed geese near Karzok Gumpa and at the southern extremity of the lake. Tso Morari is thus the most important lake for nesting water birds in Ladakh. Here I noted a pair of black-necked grebes (Podiceps nigricollis) with 5 downy chicks. This is the 1st record for Ladakh and Tibet. More important, however, is the location of a pair of black-necked cranes with 1 large young on the marsh off the southern end of the lake.

On my way to Chusul I examined the Howrang Marsh, but this otherwise very suitable marsh is too heavily grazed by yaks for cranes to nest therein.

The Pangong Tso is a large and very beautiful lake, but its water is exceptionally saline and therefore no life can survive in it. Only at the mouths of streams are there suitable areas for bird life. These, however, are not suitable for nesting cranes, though birds might visit the areas to feed.

The extensive marsh bordering the Indus River south of the Tsaka La appears to be very fine crane-nesting habitat, but it could not be examined thoroughly because it is very close to the no-man's-land bordering Tibet.

Some excellent meadows border the Indus near Leh. Local villagers at Shushot village gave me very graphic descriptions of the Trung Trung, which occasionally visit these meadows in autumn, perhaps before migration. The villagers are emphatic about the cranes not wintering on the Indus River at Leh, which suggests that they are only summer visitors to Ladakh. This idea is supported by the fact that all the other crane habitats are over 3,965 m elevation and there would be no unfrozen water during the very severe winters.

The Shyok Valley across the Ladakh Range, and Zasskar to the west of the Rupshu, are scoured by deep gorges and unfit for cranes. They also lack suitable areas to winter in, largely being too precipitous and dry.

DISCUSSIONS AND CONCLUSIONS

It is well-known that the Tibetan Plateau, of which Ladakh is a western extension, is progressively drying



Fig. 3. Cranes wintering in Bhutan glean in fields and meadows along with cattle. However, they prefer the wetter areas on the edges of fields and meadows. The birds tolerate close approach by domestic animals and local peasants.



Fig. 4. This fine pair feeding among stubble immediately became alert at the sound of a barely audible 0.22 shot and took flight shortly thereafter. This behavior tends to authenticate the Bhutanese claim that birds have been seed with damaged legs, suggesting that they had been fired on in their summer breeding range in India.

up. From the indications of glacial deposits, very extensive icecaps covered the Sasar Kangri north of the Shyok Valley and the Karakorams to the west, the Pangong and Ladkh Ranges north of the Indus, the Stok Kangri and the Taklang La Ranges to its south, and the central Rupshu Highlands between the Tso Kar Depression and Tso Morari. Icecaps continued in a continuous arc all along the Himalayan Range. Melt waters from these great ice sheets filled extensive lakes and broad marshes of the Indus Valley south of Leh, the Chusul Basin, the Indus Plain south of Tsaka La, and the Tso Kar Depression. Tso Morari had a greater depth with water spreading out into broad marshes west of Karzok Gumpa and in the south. Shorelines are visible everywhere.

Both the Pangong Tso and the Howrang marshes occupy former glacier valleys. The deep valleys of western Ladakh must have been eroded by water below the great glaciers; the degree of erosion can only be explained by massive flows of water. Thus, in the glacial age, the great glacial arc and the icecaps occupying the other mountain ranges running across the Tibetan Plateau, and enclosing the Tsaidam and Sinkiang depressions, must have provided water for lakes and marshes that made the entire central highland of Asia a great wetland, the ideal location for the central Asian wetland avifauna to evolve. The black-necked crane is 1

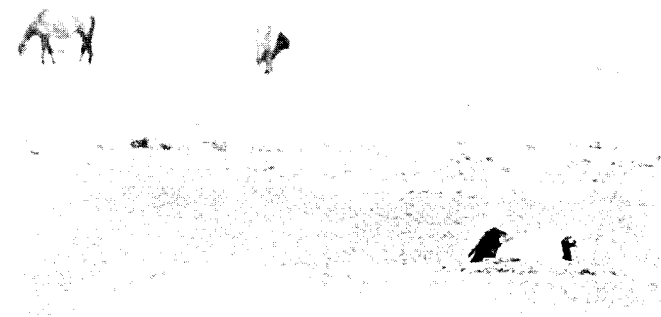


Fig. 5. The incubating bird was often disturbed by yak and ponies who waded out to feed on the aquatic weeds. Snowmelt in June can raise the water level several meters.

of the typical species. Chusul, Tso Kar, and the Indus plain at Dungti are the western limits of its range enclosed by the great icecaps to the west.

All the lakes and marshes of the Tibetan Plateau are still in the process of rapidly drying up. They represent a greatly fragmented range and the typical wetland avifauna can be considered as a relict of a more benign epoch. 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.

The black-necked cranes in Ladakh, and for that matter over much of the Tibetan Plateau, never were very plentiful, even when they and the other forms of wildlife enjoyed almost total immunity from man. The species has survived. However, with the recent increase in human activities around wetlands, the cranes will be lost very quickly unless stringent protection is provided. Primarily because of hunting, cranes have been lost in the Apa Tani Valley, otherwise an ideal habitat. In Ladakh there appears to be a greater indirect threat to the breeding cranes by more intensified grazing by domestic stock, notably yak.

It is imperative to remember that no amount of protection accorded to the cranes in Ladakh, or in the wintering locations south of the Himalayas, ensure the future survival of the species. The Peoples Republic of China must undertake a major conservation program for the species because the Indian and Bhutan crane habitats are on the very fringes of the range. The Ladakh breeding birds also go into China to winter and cranes from Bhutan go into Tibet for nesting.

My own observations in Bhutan, substantiated by those of earlier ornithologists in southeastern Tibet and Szechwan, show that although the black-necked cranes prefer sedge bogs to forage in during winter, they are markedly less aquatic than the sarus (*G. antigone*) and the highly aquatic Siberian white cranes (*G. leucogeranus*). Thus, they are less likely to be vulnerable on account of habitat alterations, and would be able to adjust to changes in their habitat in Bhutan. It is imperative that their roosting bogs be protected because otherwise the cranes would be exposed to predators.

In Ladakh, nesting lakes and potential nesting lakes, at all the locations where the cranes have been recorded during the survey and by earlier observers, are very heavily disturbed by domestic livestock. The number of ravens has also increased around the permanent settlements. Ravens may be a considerable threat to eggs.

It is difficult to estimate the number of black-necked cranes in Tibet. In Ladakh there are 3 known pairs: 1 at Chusul, 1 at Hanle, and 1 at the southern end of Tso Morari. Another 3 pairs might be expected in the area. In Arunachal Pradesh, from what I have seen, there can be no more than 10 wintering pairs, though this number is a maximum because the Apa Tani Valley has lost its flock. The wintering population in Bhutan might be estimated at no more than 50 birds. Latest information received by me, through the ICBP World Working Group on Cranes, indicates a sizable number nesting in marshes in the Tsaidam Depression north of Tibet. Even so, I should be surprised if there are more than 10,000 black-necked cranes occupying the extensive range. I like to think that my estimates are conservative.

There are reports that the royal aviaries at Thimpu, the capital of Bhutan, possess a fine specimen of this crane. There are several captive birds in Chinese zoos. This suggests that the species does well in captivity and might lend itself to a successful captive breeding program.

The black-necked cranes are recognized by the native populations in Ladakh, Bhutan, and in the Apa Tani Valley. Information on the arrival of the birds on their seasonal grounds can be therefore easily obtained by seeking help from local informers. In Ladakh the military and paramilitary forces are taking a positive interest in conservation of wildlife.

RECOMMENDATIONS

Considering the very precarious existence of the species within our area, I strongly recommend that the following conservation actions be immediately initiated. The breeding wetlands in Ladakh, Chusul, Tso Kar, Startsapuk Tso, Hanle, and the Tso Morari be immediately declared water bird sanctuaries. The meadows bordering the 2 lakes at Chusul, at Startsapuk Tso, and the other potential nesting locations should be bordered by a rubble wall to exclude domestic animals. This type of construction is done by Ladakhis around their fields. The grass growing on these meadows may be cut by the villagers in autumn for livestock feed in winter. During winter, sheep (not goats) may be permitted to graze in limited numbers within the peripheral wall. Such enclosed meadows will encourage bar-headed geese and other Anatidae to nest around these lakes.

A game warden should be appointed, from among the local people, for each of these water meadow sanctuaries. A bonus (Rs. 1,000) should be given to each warden who can show successful nesting of cranes and other waterfowl on his area. International Crane Foundation has offered to produce large pictures of the black-necked cranes. These should be sold to raise funds, to provide capital for investing, from which the above bonuses could be paid through the Kashmir Government. All the commanders of the military and paramilitary forces in Ladakh and Arunachal Pradesh should be issued sets of these posters and crane cards appealing to them to give wide publicity to the need to extend protection to the cranes in particular, and all waterfowl in general, during winter. The commanders cooperation should be solicited in ensuring the viability of areas declared sanctuaries. Posters showing endangered and protected wildlife and the game laws of the country should be issued in a small booklet form to all units of the military and paramilitary.

The Bhutan Government should be requested to instruct their Forest Department to find and report other locations where these cranes winter. A field party subsequently should visit the locations to find roosts. All roosts should be fenced and their water depth augmented. IWRB and ICF should consider the feasibility of establishing feeding posts for the cranes wintering at Boomthang. These cranes would provide a considerable tourist attraction. Cranes are regularly fed in Japan.

Posters of cranes should be issued by the Forest Department to all schools and village councils in Arunachal Pradesh. A special appeal should be made to village elders in Apa Tani Valley to accord full protection to black-necked cranes. All important wetlands in Arunachal Pradesh should be identified and ground surveys to study these should be undertaken by

multidisciplinary teams, including representatives from the Bombay Natural History Society and Zoological Survey of India. Such wetlands, notably the marsh south of Seppa in Kameng Division and the Tale Valley east of the Apa Tani Valley, should be declared sanctuaries regardless of whether or not cranes visit them.

Further study of the biology of the cranes is needed in Bhutan during winter and in Ladakh during nesting. Such in-depth studies would be undertaken by postgraduate students selected from Indian Universities and affiliated with the Bombay Natural History Society.

Careful consideration should be given to collecting eggs to start a captive breeding program. Capture of adult pairs from the Boomthang wintering flock also may be worth considering. In this regard, I make the following recommendations. Immediately after acquiring information about crane pairs nesting in protected locations in Ladakh, the Army should be requested to send the information to Delhi. One egg should be collected and rapidly transferred to Leh. The details could be worked out after IWRB clearance with the government of India. Collecting 1 egg from each nest would not endanger the species and would help increase the world population. The operation would highlight the need for conservation by the public and would generate considerable interest, essential ingredients to produce lasting results in a democratic society. A captive population should be established on the meadows along the Indus River near Leh. These cranes would provide considerable attraction to visiting tourists and would be self-sustaining.

If the Government of Bhutan agrees to having a pair captured at Boomthang, common cranes (*G. grus*) in Saurashtra should be experimentally baited with drugged grain before attempting to capture pairs in Bhutan. This trapping attempt should only be made after its efficaciousness is amply demonstrated on the common cranes. Such captures might be done more safely in wintering areas in China.

Acknowledgments.--Any field survey of this type, specially undertaken in such difficult areas like Ladakh, Bhutan, and Arunachal Pradesh depends on the support of a very wide spectra of society, from the highest Government officers in the air-conditioned offices of New Delhi to the most humble yak herder or forest tribal. It was a pleasure to work with and among them all. Thanking all the individuals is impossible. Dr. Salim Ali and Dr. D. Ripley, renowned ornithologists, have greatly encouraged me in a field where the amateur is progressively being outmoded by the qualified expert. Drs. George Archibald and Ron Sauey of the International Crane Foundation have taken a very personal interest in this project and have been instrumental in getting me into the field.

At Delhi, Shri Nalni Jayal IAS, Joint Secretary, Ministry of Agriculture, and General Sion, Commander of the Border Roads Organization, provided their official blessings which considerably eased difficulties in the field. Shri Thangam, IFS, the Chief Conservator of Forest, Arunachal Pradesh, and Shri S. S. Bhatti, IFS, the Chief Wildlife Warden, were of great help. Shri Bhatti accompanied me on an extended field trip into Arunachal Pradesh. The Border Roads organization in Bhutan made an otherwise very difficult survey the most luxurious excursion I have ever undertaken. In Ladakh, Shri S. S. Rizvi, the Development Commissioner, extended me official backing and I was most hospitably treated by several Army officers. The

Indo Tibetan Border Police had assured me assistance should I have required it. The men of the military and police forces were very kind to me whenever I met them in the field.

Excellent assistance was given me by Sonam Angchuk of Shushot village who accompanied me through Ladakh. S. S. Saha of the ZSI was a great companion in Bhutan and Arunachal Pradesh. At World Wildlife Fund-India, I am grateful to Mrs. D. S. Variava and Mrs. Rajeshwari Tandon for providing the backup support as and when I needed it. Special thanks to Shri S. R. Nayak for attending to the photographic requirements of the survey and Shri J. A. D'mello for typing the drafts of this report. Naishadh Shashtri of Rajkot assisted in typing the final report. I give special thanks to my friend and coinvestigator, Prakash Gole of Pune.

APPENDIX 1

WORLD WILDLIFE FUND--INDIA FIELD REPORT ON BLACK-NECKED CRANE WINTERING IN CENTRAL BHUTAN

On the information supplied by H. R. H. the Tengilemp to Dr. Salim Ali, a short visit to Boomthang and eastern Bhutan was included in the project to investigate the black-necked cranes reported to regularly winter in the Apa Tani Valley of Arunachal Pradesh. This brief report deals with the findings at Boomthang after observing the cranes wintering there from 15 to 20 January 1978.

The visit to the 2nd wintering area near Tashiyansi in eastern Bhutan, where a flock had been reported by collectors of the Zoological Survey of India in November-December 1973, had to be cancelled because of road blockages. Other than taking up more than a week of the time needed for locating the Apa Tani flock, little extra information would have been gained by going there by an alternative route.

Here is a brief report on my findings in Bhutan:

1. The Boomthang flock, an estimated 20 birds, is a traditional wintering population which is well known to the local people. The birds leave for the nesting grounds en masse in March. They perform spectacular displays with much calling and dancing before they leave.
2. Unlike the common crane, to which they have a strong resemblance, the black-necked cranes do not forage in a flock but do so in widely separated pairs or family groups. Though they alight in plowed fields, they prefer wet pastures and boggy ground where springs and snowmelt water spreads out.
3. Their diet appears to be largely composed of animal matter, of which the bulk seems to be earthworms, which are abundant in the wet soil, and hibernating frogs, which are dug with their powerful beaks. Tadpoles, fish (?), mollusks, and insect larvae appear to be picked from the running water. Collections have been made for identification by Shri S. Saha of the Zoological Survey of India. Birds were seen digging up bulbs of a marsh plant which also has been collected for identification.
4. Among the 20 birds seen, only 5 were juveniles. One pair had a single chick and 2 pairs had 2 chicks each. The other 4 pairs had no young. One bird had apparently lost its mate. This indicates

that although both siblings are reared on favorable breeding sites, a majority of breeding pairs appear unable to raise a single young. The mortality rate therefore appears to be very high.

5. The birds under observation appear to be very quiet and were heard calling only when taking flight. Their call resembled that of the common crane. They sounded the loud trumpeting calls only once as the flock flew into roost after dusk. The loud trumpeting calls were louder than those of the common crane.
6. The entire Boomthang population sleeps on a small sedge bog (about 1 ha) on the mountainside above Konkhar village near the 2-km mark on the road from Baykar Dzong to Tashigong in eastern Bhutan. This bog must be preserved and no attempts made to drain it. It is recommended that the bog be irrigated from a nearby stream and the water retained in the bog by a raised bank built along the road.
7. The continued existence of this wetland is of great importance for the Boomthang cranes because it is the only roosting site which has been traditionally used by the birds. The birds do not roost on islands in the river, contrary to popular local belief. In fact, there are no suitable islands for them to roost on. All the bogs are being reclaimed for cultivation and even the roosting bog has been partly drained and plowed.
8. I have made the Dzondar of Baykar Dzong's aware of the importance of the latter wetland and its location has been noted by the Baykar authorities.
9. Except for possible drainage of the roosting bog, the cranes at Boomthang are not endangered. The local authorities have extraordinary control on all forms of hunting and fishing. Local sentiments in favor of the "Thung Thung" are as strong as are those for the sarus crane in India.

My impressions are that the Bhutan authorities could very effectively supply data on other populations wintering in similar valleys. A detailed census of all wintering cranes in Bhutan is recommended in collaboration with the Government.

It is quite apparent that a captive breeding program would be a wise conservation action because a large percentage of young seem to be lost and in years to come the wild population will need to adapt to environmental changes resulting from technological advancement being applied to the agricultural practices in Tibet.

APPENDIX 2

WORLD WILDLIFE FUND--INDIA FIELD REPORT ON BLACK-NECKED CRANE WINTERING IN ARUNACHAL PRADESH

Shri Bhatti and I were in the field from 27 January to 5 February 1978. The main area of interest was the Apa Tani Valley in the Subansiri Division of Arunachal Pradesh. This unique Valley is situated at a little below 600 m elevation and is intensively cultivated. The entire valley floor is terraced for rice and an intricate system of irrigation ditches divert water from the mountain torrents that flow into the valley. The surplus water is drained off by the gentle Kale River which leaves the valley on the south by a narrow gorge to go on to join the Ranga River which flows to the plains of Assam and on to the Brahmaputra River.

Before leaving for the Apa Tani country I questioned the several educated tribals working the Arunachal Pradesh Chief Conservator's office at Itanagar with the active assistance of Shri Mehta, IFS. It was apparent that the Apa Tanis knew the bird well and very quickly identified the "Kengda" from a drawing I made to show them. They were unanimous in confirming that the bird had been a regular winter visitor to their valley some 10 years ago but they had not been seen in the same numbers now for several years. Two cranes had visited the valley and had been shot and eaten. The tribals attributed the decline of the species in the area to the great many guns now owned by the Apa Tanis. Formerly, the tribals could not kill the cranes with their arrows. The villagers in the valley itself confirmed all this including the fact that 2 birds had come 2 years previous and been shot and eaten by the tribals. They further informed me that in former times, women and children were permitted to approach closely, but the same birds showed a wariness to men, especially those with bows and arrows. This conforms to the behavior of common cranes in India where peasants working in their fields are allowed to approach very close but shikaris with guns are recognized at a distance.

The valley is still very suitable for the cranes despite the new buildings, roads, and airfield. The practices of keeping the fallow fields half filled with water, instead of the dry stubble so characteristic of paddy fields after harvest elsewhere, makes ideal feeding habitat for the cranes. The water and resultant soft soil would be to their liking.

Along with the paddy fields, there is also still considerable sedge bog along the edges of the fields and the Kale River. The tribals have started fish culture in the rice fields, introducing carp fingerlings in spring. The uncaught fish, along with the tadpoles, hibernating frogs, and earthworms, would provide ample foraging material for the cranes and, if the villagers could be induced to protect the "Kengdas," it is likely that they may once again start wintering here. It is difficult to enforce protective action without getting the village elders to speak to their people. The reader must appreciate that tribals seek as food all forms of flesh, including rodents, and crane meat would be irresistible.

Assisted by Chief Wildlife Warden of Arunachal Pradesh, Shri S. S. Bhatti, I scanned the entire expanse of the vale with field glasses but could not see any cranes. We then visited Tale Valley about 25 km east of Apa Tani Valley. This valley is over 2,000 m above

sea level, almost entirely occupied by a marsh, and overgrown with dense thickets of bamboo and isolated stands of conifers (*Thuja* sp.), rhododendron, and *Acer* sp. Although unique, the habitat is totally unsuitable, or at least the section traversed was, for cranes. We spent 1 day trying to get to the northern end of the valley where the map shows 2 large marshes which I expected might be free of bamboos. We could not get more than 5 km through the heavy bamboo brakes and the attempt had to be abandoned.

The tribals from Kameng District in west Arunachal Pradesh recognize the "Trung Trung" but I suspect this is less because they have actually seen the living birds than that the bird is associated with lamaist legends and drawings in the monasteries. However, there can be little doubt that the cranes do occur sporadically in the upper valleys along the Tibetan border. I believe that if there are any broad valleys near the border, the cranes would be visiting them regularly. Information about such locations is not forthcoming from the officials and it is unlikely that large valleys of any size exist. The question would be easily solved by studying maps. I have, however, not been able to acquire any topographical sheets.

In summary, I express the following opinions:

1. The black-necked crane has stopped coming to the Apa Tani Valley primarily because of persecution by the tribals during the last 2 decades since the issue of guns.
2. Cranes would again start coming if the villagers could be induced to protect them. Despite great development in the Valley, the area is still very suitable for them.
3. Until proved to the contrary, there are chances of a few birds visiting marshes in northern Tale valley. Suitable valleys would be worth examining along the Tibetan border.

My recommendations are as follows:

1. The Arunachal Pradesh authorities should be requested to instruct the civil authorities to assist the Chief Wildlife Warden of the state to develop an opinion favorable to the cranes. Cooperation of the tribal elders should be sought.
2. A careful study of topographical sheets should be authorized by government to locate possible high-altitude valleys where cranes might be found.

Brolga and Sarus Cranes



Brolga (left) and sarus cranes (photos by L. Walkinshaw).

INTRODUCING THE SAROLGA

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The sarus crane (*Grus antigone*) was first unofficially identified in Australia on 13 September 1964, by Dr. and Mrs. William Citterell of Harvard University and Mr. James Bravery of Atherton, Australia. The cranes were observed at Hasties and Willets Swamps on the Atherton Tableland, Queensland. Unfortunately the photograph they took was not good enough to permit positive identification. It was not until 13 October 1966 that a party made up of Mrs. Gill of Innisfail, Queensland, Mr. Eric Zillman of Queensland, and Fred Smith of Victoria officially recorded sarus cranes at Normanton (Gill 1969). A photograph by Zillman was sent to Alex Chisholm of Sydney, who confirmed the identification. On 16 September 1967, Chisholm published a picture of the species in the Sydney Morning Herald.

On 27 July 1967, Mr. Jim Bravery and Mr. Bruce Cook of Marselia, Queensland, saw 23 sarus and over 80 brolgas (*Grus rubicunda*) at Willits Swamp. Included were several immature sarus (Bravery 1969). Dr. Lawrence Walkinshaw studied sarus cranes on the Atherton Tableland in 1969, and specimens were collected by Lavery and Blackman in the same area in 1970. Lavery and Blackman (1969) confirmed the form as the eastern sarus crane (*G. antigone sharpii*), a uniformly gray bird, contrasting to the white-collared and larger Indian form, the common sarus (*G. antigone antigone*). Blackman (1971) summarizes the observations of sarus cranes in Queensland as covering 880 km from Aurukum to Normanton and from Normanton along the Gulf of Carpentaria (960 km) east to Ingham on the east coast of the continent. Ridpath (pers. comm., 1972) reported that the species had unofficially been recorded in Northern Territories. Slater (1970) reports the range of the species as extending from Queensland's west to the Kimberley Plateau of Western Australia. In 1972 the author saw 2 sarus cranes near Kununurra in northeastern Western Australia and about 200 on the Atherton Tableland of Queensland.

ATHERTON TABLELAND CRANES

Cranes of the Atherton Tableland were studied from 1 November to 14 December 1972. Approximately 200 sarus and 30 brolgas were present during the 1st 2 weeks of the study. The 1st rain of the wet season came on 15 November and from then until 9 December the sarus numbers decreased as birds supposedly migrated west to the breeding grounds. From 10 to 14 December the only cranes observed on the Tableland were brolgas.

Both species roosted at Willets Swamp and on the shores of Lake Tinaroo. Generally the species roosted in loose but separate flocks. At dawn they typically unison called, preened, then flew to feeding areas on the recently plowed maize fields. Sarus and brolga usually flew and fed in separate flocks; however, it was not uncommon to see the species together. In late morning the birds either circled up the hot thermals and disappeared from view, or they flew directly to drinking areas--springs, small streams, Willets Swamp, or Lake Tinaroo. By late afternoon they usually had returned to the fields to feed and at dusk they returned to waterside roosts. From late November until they departed in December the sexual display activities of sarus increased (dancing, unison calling) both at the roosts and in the fields.

I was unable to discern any difference in habitat used by sarus and the brolgas on the Atherton Tableland. Both species had similar daily movements and fed on the same materials in the fields (corn, rats, insects) and in the marshes (sedge tubers, aquatic animals). Although no ecological difference was noted between the species, their anatomy and displays are quite divergent.

The sarus are slightly larger than the brolgas. Whereas the brolga has about 5 cm of red headcomb, the sarus comb extends from the head about 12 cm down the neck. The brolgas have a pronounced gular sac beneath the chin and the sarus have none. The brolgas are a shiny light gray, but the sarus are a dull steel gray. The brolga has a graceful stance with its long, curved neck and slender body, while the sarus is a stockier bird. The brolga's feet and legs are black, whereas those of the sarus are pink. Brolgas have a much deeper, raucous voice contrasted to the shrill, higher voice of the sarus. When dancing the brolga makes many bouncy leaps in the air; the sarus has a more graceful dance, makes long runs with wings spread, and then makes deep bows.

THE SAROLGA

Among the 200 sarus on the Atherton Tableland in 1972, there were at least 2 and possibly 6 hybrids between sarus and brolga hybrids, which for convenience will be called sarolgas. Each time a sarolga was observed it was with a small flock of apparently nonbreeding sarus (chicks were absent from the flocks). The 1st sarolga was collected and is described below. Soon after that a 2nd sarolga was observed with sarus cranes. This observation was repeated on 4 subsequent occasions. One adult bird believed to be backcross progeny from a sarolga-sarus breeding was observed and photographed with more than 100 sarus at a water hole. Once at midday a sarus female and brolga male pair were observed in company with 8 other brolgas at Willets Swamp.

The sarolgas are perhaps an example of hybrid vigor because they appear larger than even the sarus, which is larger than the brolga. Table 1 and Figure 1 present the measurements and other characteristics of the collected male sarolga, and these are compared to similar characteristics of adult male sarus and brolga. Basically the sarolga looks like a huge brolga. Sarus features were size, pink tibia, hock joints, and feet. Brolga features were notched comb, black tarsi, and the graceful brolga body conformation and plumage color. Intermediate characteristics were comb and gular sac size. Weight, tarsus, and culmen measurements exceeded those of both sarus and brolga. Other sarolgas observed appeared to have characteristics similar to the collected bird.

The supposed sarolga-sarus backcross progeny looked like a sarus except for darkened tarsi, reduced comb, and the notched comb pattern. The existence of a backcross would indicate the reproductive capability and the evolutionary potential of the sarolga.

DISCUSSION

The sarus discovery in 1964 and the apparent population increase, coupled with the 1972 discovery of

Table 1. Characteristics of male sarus, sarolga, and brolga cranes.

Characteristic	Sarus (N = 5 males)	Sarolga (N = 1 male)	Brolga (N = 4 males)
Weight (kg)	8.4	9.5	6.8
Culmen (mm)	162.3	177.8	164.4
Tarsus (mm)	296.0	317.5	304.9
Comb (mm)	127.0	107.8	508.0
Iris	Yellow	Yellow	Yellow
Comb pattern	Even	Notched	Notched
Tibia	Pink	Pink	Black
Ankle joint	Pink	Pink	Black
Tarsus	Pink	Black	Black
Feet	Pink	Pink	Black
Body conformation	Stocky	Graceful	Graceful
Plumage color	Slaty gray	Light shiny gray	Light shiny gray
Gular sac	Absent	Present but small size	Present

interbreeding with brolgas, has posed some interesting questions. Where did the sarus come from? How long have they been in Australia? What is their future there? What is the future of the brolga in relation to the presence of the sarus?

The pre-1964 range of the sarus was believed to extend from Assam to Vietnam and south to the northern parts of the Malay Peninsula--basically, southeast Asia. It is not considered a bird of the Philippines, Indonesia, and the island of New Guinea, although there are a few scattered records from the Philippines. Brolgas, or at least what are believed to be brolgas, breed in southern New Guinea. From existing evidence it seems probable that the sarus immigrated 3,480 km from southeast Asia to Cape York, Australia, in the early 1960's.

Some ornithologists argue that the sarus may have been in Australia for many years and simply went unnoticed. They reason that the sarus were considered brolgas in breeding condition because the comb is larger and brighter in the breeding season. However, northern Australia has been the site of many ornithological investigations. Surely all of these trained observers would not have confused the sarus and the brolga. My theory that the sarus recently arrived in Australia is supported by the facts that the bird was not recognized until 1964 and that they have subsequently increased at an apparently rapid rate, and their range is expanding.

Perhaps the best evidence for the recent arrival of the sarus is the presence of sarolgas. The sarus and brolgas will interbreed, and the hybrids are fertile. If the sarus had been in Australia for many decades, an observer might expect to find introgressing of the 2 species into a new crane form. Introgression was evidenced only by the possible 6 sarolgas, the 1 supposed backcross progeny of a sarolga-sarus breeding,

and the apparent pure brolga-pure sarus pair, suggesting that the reproductive barrier between these species--geographic separation--was recently broken and interbreeding was only recently possible. The fertility of the sarolga was verified in Jean Delacour's aviaries in France in 1934; sarolgas produced in captivity were fertile (Gray 1958).

The future for the sarus in Australia is bright. They are larger than the brolgas, have apparently adapted well to Australian environment, and are increasing and expanding their range. In contrast, the future of the brolga may be shadowed by the presence of the sarus. The greatest problem for sarus-brolga coexistence may be the breeding habitats. Both species nest and rear their chicks in marshlands, and pairs defend large areas of marshland as breeding territory. The unanswered questions are--Do the sarus use the same types of marshes as the brolgas, and if they do, what is the interaction between the species?

Walkinshaw (1973) observed both sarus and brolgas breeding in the Normanton area of Queensland. He relates that the sarus prefer upland prairie-like marshes, while the brolgas keep more to the low coastal marshes. This tendency is also mirrored during the nonbreeding season, when the sarus frequent more upland agricultural-type areas while the brolgas' greatest congregations are along the coastal marshes, where they subsist primarily on tubers (Blackman 1971). It appears that, at least when the sarus numbers were low, there was a niche divergence between the species. However, if their numbers continue to increase, as they apparently have been, we might expect sarus to move into less-preferred habitat--probably the brolgas' breeding marshes. Sarus are significantly larger than brolgas. It may be that they will establish dominance over the brolgas and displace them from their breeding habitats. The future for the brolga is bleak if such competition develops.

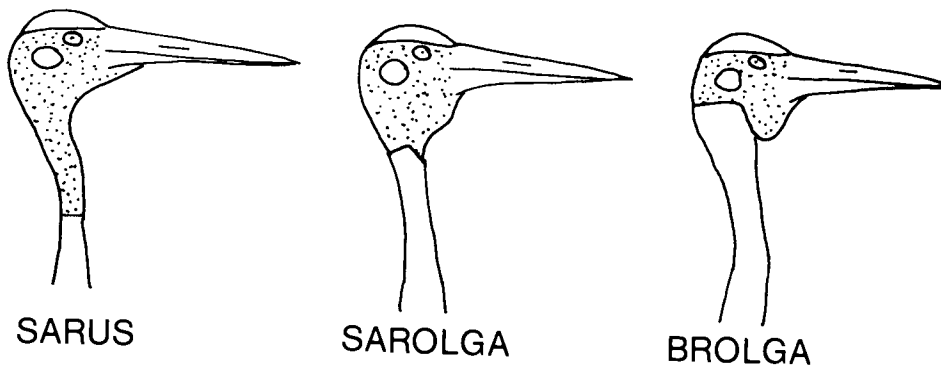


Fig. 1. Comparison of head comb (dotted areas) of sarus, sarolga, and brolga.

However, if introgressing continues at a significant rate, we can eventually expect the evolution of a type of sarolga. Divergent evolution of the 2 species to occupy distinct niches and thus avoid competition, interbreeding to a species swarm, or the eventual extinction of the brolga are all possibilities. It will be most interesting to observe future crane events in Australia.

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SEARCH FOR THE EASTERN SARUS CRANE ON LUZON, PHILIPPINES¹

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Abstract: A search for the eastern sarus crane (*Grus antigone sharpii*) was conducted on Luzon, the Republic of the Philippines, from June to December 1979. The study areas were the Cagayan Valley, Tabuk in Kalinga-Apayao Province, and the Candaba Swamp in Pampanga Province. Information concerning sightings was gathered directly from local people. Sightings were reported in Ilagan, Cauayan, and Jones of Isabela Province in Cagayan Valley, and in Tabuk of Kalinga-Apayao Province. In Jones, Ilagan, and Cauayan municipalities, people reported having seen eastern sarus cranes in the early and mid-1960's, but not since then. People in Tabuk claim that the crane was abundant in the early 1940's but their population quickly declined when the human population increased. In the early 1970's only 2 sightings were reported. In 1979 a crane pair was reported seen regularly flying over Tabuk but I failed to find them. The crane's flat, swampy habitat is suitable for rice cultivation. Farmers on Luzon continue to destroy crane habitat while preparing wetlands for rice cultivation. Without the tall grass cover of the original crane habitat, hunters have easily decimated the eastern sarus crane populations. Although a few individuals may still exist, it is unlikely that a sizeable crane population remains on Luzon.

The objective of this study was to determine the status of eastern sarus crane populations on the island of Luzon, Republic of the Philippines. The survey was conducted from June 1979 to December 1979. The eastern sarus crane is one of the largest flying birds. It has a grey body. The head and upper neck are red and naked except for sparse, black hairlike feathers. The crane reaches sexual maturity at 34 months and lays 2 eggs a year; usually only 1 egg hatches (Dr. George Archibald, per. comm.).

According to McGregor (1909) the eastern sarus crane was abundant in Cabanatuan of Nueva Ecija Province. Delacour and Mayr (1946) found it breeding in Nueva Ecija in open swampy areas. Large numbers were seen by Worcester (cited in McGregor 1909) in the provinces of Cagayan and Isabela in northern Luzon and in the Candaba Swamp of southcentral Luzon. Worcester was informed that eastern sarus cranes nest in May and in August they lose their flight feathers. He learned that the people of Isabela lassoed the vulnerable cranes in August when the birds were flightless (McGregor 1909).

In India the sarus crane (*G. antigone*) lives in flooded rice paddies (Al 1964). There the sarus crane is not harassed because the people believe it is bad luck to kill cranes (Whistler 1949).

STUDY AREA

The Cagayan Valley extends north-south of north-eastern Luzon (Fig. 1). The Sierra Madre Mountain Range borders the east, the Cordillera Central Range borders the west, and the Cagayan River runs the length of the Cagayan Valley. The western side of the Cagayan River contains cultivated rice or corn interspersed with shortgrass areas grazed by cattle. The area east of the Cagayan River to the Sierra Madre Mountains is largely unexplored except by the native inhabitants. Most roads do not extend more than 40 km east of Cagayan River, but there are some logging roads. The central Cagayan Valley is heavily populated.

Formerly the plains of the Cagayan Valley contained large expanses of natural wetland. Tall grasses occurred on the plains and dipterocarp forest covered the highlands farther from the Cagayan River. The forests were logged by the Spanish in the 1600's and

1700's. Now most of the natural wetlands are cultivated with irrigated rice year-round or with rice during the rainy season (June to October) and with corn during the dry season (November to May). Short grasses have replaced the tall grasses in areas that are not cultivated. Much of the natural wetlands dry up during the dry season because irrigation canals divert water to other areas. The temperatures in the Cagayan Valley range from 15 to 40°C and the average annual rainfall is 1.7 m (Dickerson 1928).

Tabuk, Kalinga-Apayao Province is located west of the Cagayan Valley, in the foothills of the Cordillera Central Mountains. There the temperature and rainfall are similar to those of the Cagayan Valley. Low rolling, grass-covered hills, flat-topped mesas, and the Chico River Basin dominate the area. Before the 1700's dipterocarp forest covered the hills, but in a short time the native's kaingan (swidden) agriculture destroyed the forests and forest soil. Tall cogon grasses grew on the mesas and in swampy areas. Now approximately 70% of the tall grasses have been replaced by short grasses, rice, or corn. The short-grass hills are grazed by cattle.

The Candaba Swamp of Pampanga Province is 50 km north of Manila. The swamp is approximately 300 km² of flat terrain that is easily flooded during the rainy season. Temperatures in the Candaba Swamp range from 16 to 37°C with rainfall around 0.8 m during the rainy season and less than 0.1 m during the dry season (Dickerson 1928).

Candaba Swamp was formerly an ideal wetland with areas of open and shallow water, sedges, mangroves, and numerous and varied grasses. Fishing occurred year-round. Since the 1950's to 1960's most of the Candaba Swamp has been cultivated with rice during the rainy season and with melons during the dry season. The area is now heavily populated and much of the swampland has been drained to divert the water elsewhere. A few small and scattered mangrove swamps still exist in the western portion of Candaba Swamp.

METHODS

Municipalities in the Philippines encompass large rural areas and an urban center. Municipalities are subdivided into barangays with a captain appointed to each. Municipal mayors frequently meet with barangay captains and have contact with even the most remote barangays. Gathering information about an area is most easily initiated in the Mayor's Office.

¹Research sponsored in part by the Delaware Museum of Natural History.

Most municipalities of the Cagayan Valley and some municipalities of the Candaba Swamp were visited. Municipalities visited were Alcala, Allacapan, Amulung, Aparri, Baggao, Ballesteros, Buguey, Gattaran, Penablanca, Piat, Solana, and Tuguegarao of Cagayan Province; Angadanan, Cabagan, Cabanatuan, Cauayan, Echague, Ilagan, Jones, San Augustine, Santiago, and Tumauini of Isabela Province; Tabuk of Kalinga-Apayao Province; and Arayat and Candaba of Pampanga Province.

The Mayor's Office was contacted after arrival in a municipality. The Mayor's Office provided information concerning (1) the history of the area including past human population densities and distributions, previous agricultural and logging operations, and original vegetation and wildlife; (2) the names of individuals who may have information about wildlife; and (3) the names of barangays and barangay captains located near probable eastern sarus crane habitat. The mayors were asked to circulate a pamphlet written in Ilokano, 1 of the most common local dialects. The pamphlet contained a sketch of the eastern sarus crane, an explanation of the crane search, and offered a reward for information leading to discovery of the crane.

The barangays were visited after talking to people in the urban center. Barangay captains were briefed on the project and asked if they had seen or knew anyone else who had seen an eastern sarus crane. People recommended by the barangay captain were interviewed. People claiming they had seen cranes were asked the frequency of their sightings, when, where, how many birds they had seen, and the bird's activities. Additional questions were asked about the vegetation and topography at the sighting location. All possible leads were pursued during the search.

RESULTS

The only eastern sarus crane sightings reported were in the Cagayan Valley and in nearby Tabuk of Kalinga-Apayao Province. Eastern sarus cranes were reportedly seen in the Cagayan Valley in Jones, Echague, Cauayan, and Ilagan municipalities, all within Isabela Province.

In Jones, 1 person was found who had seen the eastern sarus crane (called Camaboy in Isabela). He claimed he had chased them in the fields and swamps of Jones as a boy in the early 1940's. He also claimed he had seen 1 crane flying over Echague accompanied by approximately 30 egrets on 3 occasions. The latest sighting was in December 1979. Other people in Jones say they have not seen a crane since the late 1950's.

In Cauayan, 3 people said they had seen cranes in the early and mid-1960's. They saw 2 to 4 birds simultaneously in the tall grasses. Sightings were most frequent in May. The local people say that in the 1950's there were tall grasses and trees interspersed among the rice fields, so cranes could nest and hide in tall grasses. Since the 1960's the grasses and trees have been removed and cranes have not been seen.

There was 1 sighting reported near Ilagan. An eastern sarus crane pair was seen in the late 1960's in March (the hottest season) standing along the Cagayan River. The individual who sighted the crane was a hunter who traveled to many remote areas along the river but had never seen a crane before.

In Tabuk, 11 pioneers of the area reported seeing eastern sarus cranes (called Tipol in the local Ilokano dialect). These 11 people claim that before 1940

cranes were plentiful in the rice and grass fields of Agbannag, Nambaran, and Malalao Barangays, all within the municipality of Tabuk.

The pioneers reported that when cranes were plentiful, they nested in 1-m-tall cogon grasses, flew to river banks or rice fields to feed in the morning, and returned to the grasslands at dusk. The cranes obtained food by picking under the grass with their beaks. Some described the cranes as being "as tall as man." There were reports of 4 cranes being killed during the 1940's, 1 in 1972, and 1 in 1975.

The people in Tabuk believe that the eastern sarus crane population decreased as more people settled in the area. By the early 1970's the crane was "very rare." According to municipal officials the first non-native settlers came to Tabuk in the early 1930's. The human population increased, cultivation began in the 1950's, and by 1960 much of the area was being farmed.

In 1972 an eastern sarus crane pair was seen first in Dilag, later in Nambaran, and finally in Agbannawag Barangays of Tabuk. The hunter who killed a crane in 1975 speculates that it was 1 of the pair. During May and June of recent years a pair was seen flying over Tabuk every morning at 0700 to 0800 hours and again in the evening at 1600 to 1700 hours. At other times of year a pair was seen flying over Tabuk about twice a month. The pair has not been seen since July 1979 and attempts to find them failed.

DISCUSSION

Unfortunately there is little evidence that an eastern sarus crane population still occurs on Luzon. Habitat destruction and subsequent hunting are probable causes of the cranes' disappearance. Nearly all swampy areas and tall grasslands, which are crane habitat, have been drained or are planted to rice or

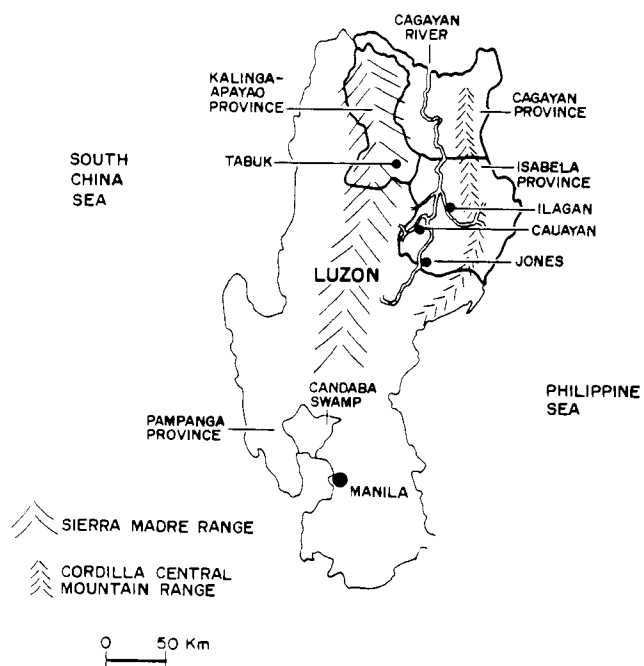


Fig. 1. Island of Luzon, Republic of the Philippines, showing study areas visited during the survey for cranes.

corn. Without adequate vegetative cover, the size of the crane makes it an easy target for hunters. Due to the low reproductive potential, crane populations cannot withstand hunting pressure.

The Indian people's belief that it is bad luck to kill a crane has allowed the sarus crane to survive in India despite the dense human population there. In contrast, Filipinos do not have a superstition concerning cranes nor a concept of wildlife conservation. Hunting and eating any animal is acceptable in Filipino culture. The vulnerability of the eastern sarus crane in the Philippines is illustrated by reports of people chasing and lassoing cranes during August when the birds are flightless. Unlike India, where the sarus crane has been able to live in rice paddies, the Philippine eastern sarus crane cannot survive without protective cover of tall grasses and sedges.

There is no evidence that the crane populations discovered by Worchester (McGreggor 1909) and Delacour and Mayr (1946) still remain. The areas previously reported as eastern sarus crane habitat are now heavily populated and cultivated. Even though Tabuk of Kalinga-Apayao Province was the most recently settled and cultivated of all the areas visited, the last remnants of a crane population could not be found there.

Information has been gathered from laymen who know the most about their locality. Results are imprecise because laymen do not record sightings scientifically. It is also not practical to rely on second-hand reports of sightings; in the field it is necessary to communicate in person. Many remote areas were not

reached because of transportation problems. It was not possible to investigate eastern areas of the Cagayan Valley because of recent political instability there. Hopefully these eastern areas and other inaccessible areas can be explored in the future.

Because of the suitability of the eastern sarus crane's habitat to rice cultivation and the importance of rice to the Philippines, most of the habitat has been destroyed. Without vegetative cover the eastern sarus crane is easily killed by the numerous hunters in the Philippines. A few isolated individuals may still exist near the Tabuk area, but it is unlikely that an extensive eastern sarus population remains in the Philippines.

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Wattled Crane



Photo by L. Walkinshaw.

STATUS AND ECOLOGY OF WATTLED CRANE IN AFRICA

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Abstract: Wattled cranes (*Bucconas carunculatus*) are distributed throughout the southern 3rd of Africa with a small separate population in the highlands of southwestern Ethiopia, inhabiting small wetlands throughout their range. Six large wetlands, the Kafue Flats, Bangweulu, Busanga, and Liuwa in Zambia, and the Okavango and Magadigadi in Botswana provide extensive floodplains which are preferred habitat for feeding and nesting. Individual wetlands support 250 to 3,000 cranes during peak seasons. These large, stately cranes, named for their 2 pendant chin wattles, feed mainly by digging nutritious sedge tubers and rhizomes with their large beak. They usually nest during the rainy season, in small wetland habitats, when ample water is available and sedge growth rejuvenates. In the large wetlands nesting takes place in expanses of open, shallow water as floodwaters recede and the floodplain margin provides large areas of sedge foods. The numbers of wattled crane pairs nesting and the amount of available food are directly related to the amount of flooding or receding water (the area of the floodplain) in the large wetlands. The wattled crane has the lowest reproductive rate of the crane family and its ecology closely resembles its closest relative, the endangered Siberian white crane (*Bucconas leucogeranus*). Wattled cranes are presently declining in numbers throughout their historic range. Small wetland habitats have been lost through habitat alteration and destruction by intensive agricultural practices, afforestation, and wetland drainage or damming. These developments and low reproductive rates have resulted in the extirpation of the wattled crane in Swaziland and Cape Province, South Africa. South Africa lists the wattled crane as an endangered species in the provinces of Natal and Transvaal. The wattled crane is declining or present only in small numbers in Zimbabwe, Malawi, Ethiopia, Namibia, Angola, Zaire, and Mozambique. The large wetlands of Zambia and Botswana are targets for large development projects including wetland reclamation (Okavango), hydroelectric schemes and damming (Kafue Flats; Bangweulu), while human pressures are suppressing the reproduction of a theoretically protected population of wattled cranes (Liuwa). The most alarming project includes the damming of the Kafue River above Kafue Flats to regulate annual flooding, thereby directly reducing the area available to feeding and nesting wattled cranes and threatening the future of their largest population. Conservation recommendations and future research needs are outlined for these cranes and the wetlands they inhabit.

The wattled crane (Fig. 1) is a truly unique member of Gruidae which inhabits some of the world's largest and biologically diverse wetland ecosystems, existing in remote regions of southcentral Africa. Due to worldwide destruction and alteration of wetlands by human activities, valuable wetland resources and their dependent wildlife communities are fast disappearing. Cranes, due to their habitat and territorial requirements, are often the 1st species affected by wetland development. The wattled crane is Africa's largest crane and requires a specialized habitat, depending on shallow wetlands and predominantly sedge-based vegetarian diet. The species is easily observed and counted due to its large size and long conspicuous white neck; thus, it is an excellent indicator species of wetland stability and human wildlife values.

The endangered status of 6 crane species (Vincent 1966), and the concern of West (1976, 1977) and Douthwaite (1974) for the wattled crane, prompted the initiation of this study. From October 1978 to March 1979, this International Crane Foundation researcher, with the financial support of the New York Zoological Society, investigated the status of wattled cranes and their wetlands in Zambia, Botswana, and South Africa, in order to document information on the biology of the species, to define conservation problems, and to propose solutions through appropriate channels in each country. This paper is a comprehensive account of the information collected during the study.

Walkinshaw (1973) and Snow (1978) have analyzed the distribution of the wattled crane in Africa (Fig. 2). The nucleus population is found in the southern 3rd of the continent (desert regions) and a separate population exists in Ethiopia.

LARGE WETLANDS

The large wetlands in the interior of southcentral Africa are international treasures of water and plant

and animal life. Formed along major river drainages, these wetlands are linked to a relatively level plateau with low gradients, widely spaced drainage networks, and high rainfall during the wet season, especially in the northern basins. In this region, 6 large wetlands were found to be of major importance to the wattled crane as resident and nesting areas. These include Kafue Flats, Bangweulu, Busanga, and Liuwa in Zambia and the Okavango in Botswana. The Magadigadi of Botswana is also included in this group because of its importance as a wet season concentration area (Fig. 3).

These large wetlands are located along the major river systems: the Zambezi, Congo, and Okavango. Kafue Flats and Busanga are formed along the Kafue River, a major tributary of the Zambezi. The Luambimba and Luanginga Rivers, which are also tributaries of the Zambezi, flood Liuwa. Bangweulu is located along the Chambezi-Luapula Rivers drainage, the headwaters of the Congo River basin. The Okavango is at the terminus of the Okavango River. The Botlete River drains southeast from the Okavango to provide limited water to the Magadigadi.

Tropical freshwater wetlands have the highest productivity of all natural communities. Tropical wetlands are complex and either have high densities of individuals or high diversities of species, or both, and have very tight nutrient cycles (Thompson 1976). Wetlands formed on river systems have a marked influence on the hydrology because they flood rapidly during the rainy season, but release water slowly as the dry season advances. The wetlands form sponges, increasing the water storage capacity of the rivers in their upper basins, thereby regulating flow and limiting the amplitude of the runoff to prevent floods downriver during the wet season and to continue to release waters to give a more continual flow to the river system during the dry season. Wetlands also store nutrients, provide natural filters, minimize

erosion, and in some circumstances recharge groundwater supplies.

The number of wattled cranes in each large wetland is probably related to the area of floodplain in each wetland. The wattled crane's nesting strategy is associated with the flooding cycles of each large wetland. Pairs begin nesting as floodwaters recede after peak flooding. The timing of flooding depends on hydrological factors unique to each wetland but factors include the amount of inflow from local precipitation, the timing of floodwaters from distant upper basins, and the amount of outflow via natural drainage and evapotranspiration. This nest initiation strategy takes advantage of large areas of shallow floodplain which "boom" with an abundance of sedges after a dormant period during high floods. The strategy ensures ample foods for the family if the nesting attempt is successful.

Migrations of wattled cranes may occur throughout the large wetlands and are necessitated by changes in habitat due to heavy seasonal flooding or dry conditions in small wetlands. The Magadigadi is used by wattled cranes solely as a wet-season concentration area; however, little is known of the movements of these birds.

The large wetlands important to wattled cranes (except Magadigadi) are also inhabited by large herds of lechwe (*Kobus lechwe*), a medium-sized antelope that has adapted to wetland floodplains where water levels are shallow enough for the herds to wade in and graze

on submergent vegetation. The lechwe and wattled cranes share the same floodplain habitat and are often seen feeding together.

The large wetlands host many levels of life, most notably the diverse plant life, trees, invertebrates, fishes, reptiles, birds, and mammals. These wetlands produce huge quantities of fish, supporting important fisheries and providing food for large human populations. They provide extensive habitats for a great variety of birdlife, which uses them for feeding, roosting, migrating, wintering, resting, moulting, or nesting. Large mammals use either the wetland proper or the vegetation of the dried floodplain for feeding, especially during the dry season, when upland grasslands are dry or burned over. Domestic livestock also use the wetland borders as pasturelands.

Large wetlands are often targets for development by agricultural, irrigation, industrial, mining, and hydroelectric interests. These developments must only be considered with great restraint. Africa is still in a development infancy and therefore must consider the consequences suffered by the loss of valuable wetlands in Europe, Asia, North America, and the Nile River system to the north (Curry-Lindahl 1972).

Kafue Flats

Kafue Flats is a large riparian floodplain encompassing over 6,000 km² along the meandering 255-km course of the Kafue River's eastward flow where the gradient falls less than 10 m over the entire

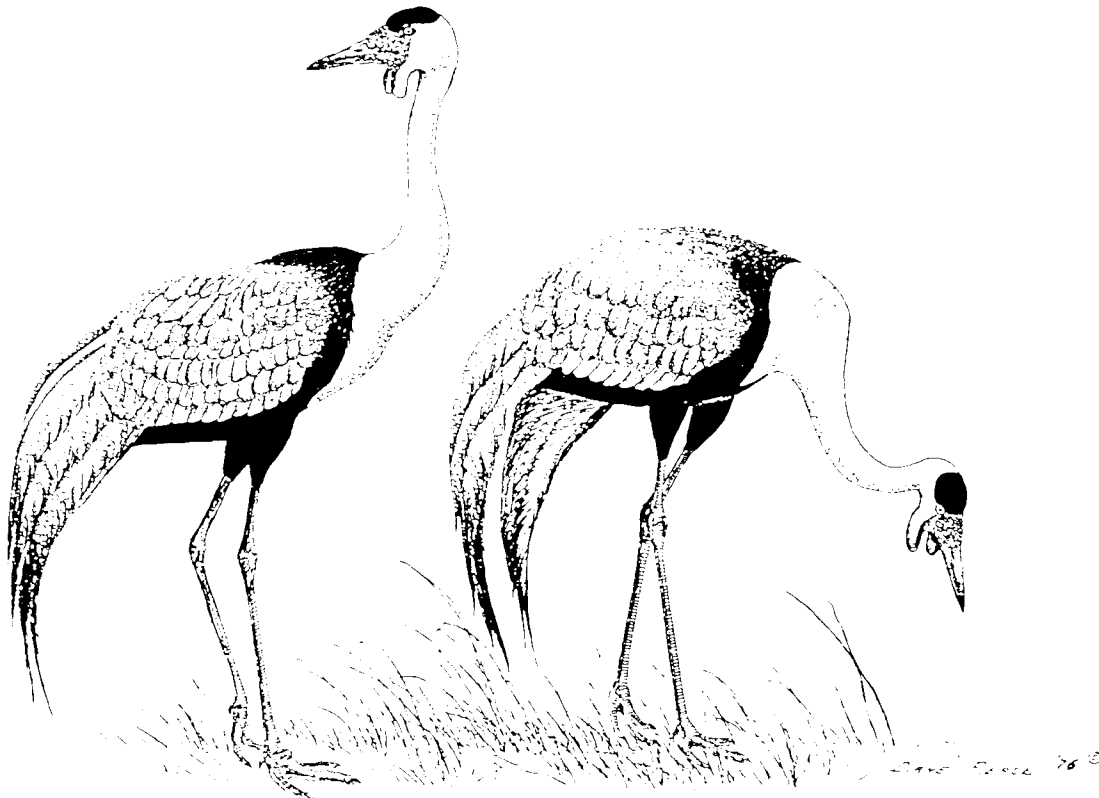


Fig. 1. Wattled crane. Ink study by Diane Pierce, courtesy of Edge of the Wild Studios, Mentor, Ohio.

flats. The flooding cycle begins with the onset of the rains in November. The greatest water volumes originate in upper Kafue Basin where rainfall is higher than on Kafue Flats (Table 1). The floods reach a peak in March on the western side of Kafue Flats, but may take until June to reach the eastern end. The timing and duration of flooding are variable from year to year, as is the extent of flooding. However, the natural flooding of the Kafue Flats is now being altered by a large hydroelectric scheme.

Kafue Flats supports Africa's largest population of wattled cranes, numbering about 300 breeding pairs and up to 3,000 individuals at peak seasons (Douthwaite 1974). These population peaks correspond with receding floodwaters which provide large areas of floodplain along the wetland edges. Vesey-FitzGerald (1965) describes the floodplain as a "water meadow grassland." When flooded this meadow comprises a semifloating sward of grasses and sedges which collapse as the water recedes, forming a thick mat with nodes growing up through the prostrate mat. As floodwaters recede the cranes are attracted to this shallow floodplain to feed on the tubers and rhizomes of submerged sedges, which are procured by digging with their large beaks.

Douthwaite (1974) lists the sedges consumed by wattled cranes on the Kafue Flats as *Cyperus esculentus*, *Cyperus usitatus*, and *Eleocharis dulcis*. Gerard Ellenbrock (pers. comm.) includes *Cyperus rotundus* and indicates that *Cyperus* rhizomes measure 3 to 5 mm in diameter, while *Eleocharis dulcis* rhizomes are at least 8 mm in diameter during the wet season and may be slightly thicker during the dry season. Although variable in area, the floodplain of shallow water and thick vegetation may extend 100 m or more from the wetland border, with water levels generally less than 1.5 m deep.

Pairs nest as floodwaters recede and provide shallow lagoons and large expanses of shallow, open floodplain as nesting habitat. Most nesting takes place from May to September with a peak in June and July. The number of pairs nesting each year is dependent on the amount of flooding. Douthwaite (1974) found that approximately 40% of the pairs observed nested in a normal year of flooding, while in a year of limited flooding only 3% of the pairs nested.

During observations on the Kafue Flats a total of 552 wattled cranes were seen (Table 2). Breeding pairs made up 64% of the total; 11% of the pairs observed were successful in raising a chick to fledging (Tables 3 and 4). Nonbreeding birds made up 32% of the population. Only 20 chicks (3.6% of the population) were observed, a very low productivity rate.

During the rainy season (November through March) wattled cranes begin feeding on sedges in moistened upland soils, but also continue feeding on the floodplain. However, during high floods the uplands become more important as the wattled cranes feed on sedge tubers and rhizomes, grass seeds, and insects (Douthwaite 1974). The high floods also mark a period of partial winter dormancy for floodplain vegetation (Vesey-FitzGerald 1965). The cranes return to the floodplains at the onset of the dry season when the flood-controlled meadows vegetate as floodwaters recede and the rain-controlled grasslands are dry and often burnt (op. cit.).

Many wattled cranes leave Kafue Flats during years of high rainfall (Douthwaite 1974), perhaps due to lower food availability during high floods. Movements

from the Kafue Flats coincide with influxes of wattled cranes into the Magadigadi of northeastern Botswana (south of Kafue Flats) where large flocks, numbering up to 2,000 in some years, moult and feed from January to May in uplands adjacent to wetlands of Magadigadi (Mark Muller, pers. comm.). The Kafue Flats population makeup is not well understood because with seasonal changes (Douthwaite 1974) some of the population of wattled cranes resides outside Kafue Flats, but uses the Flats as a staging area. Additional studies using color-coded numbered bands or radio-tags, or both, are needed to properly understand the movements of these birds in the wetlands of southcentral Africa.

The floodplains of Kafue Flats are dominated by the endemic Kafue lechwe (*Kobus lechwe kafuensis*) which has adapted to feeding in the wet meadow grasslands of the floodplains. Kafue lechwe and wattled cranes share this special habitat along with great numbers and diverse species of wading birds and waterfowl. The grazing and trampling of the submergent vegetation by lechwe opens feeding areas for many water birds. The floodplain also provides insects, snails, fishes, and other nonvegetative foods.

The floodplain of Kafue Flats provides a wildlife spectacle, with herds of thousands of lechwe grazing with many species of plovers, jacana, kingfishers, herons, ibis, storks, cranes, ducks, and geese using the floodplain in their respective foraging niches. It is a scene filled with color, motion, and a unique collage of sounds.

Sheppe and Osborne (1971) describe the pattern of floodplain use by mammals on the Kafue Flats including Kafue lechwe, zebra (*Equus gurchelli*), wildebeest (*Connochaetes taurinus*), buffalo (*Synceus caffer*), roan (*Hippotragus equinus*), reedbuck (*Redunda arundinum*), eland (*Taurotragus oryx*), hippo (*Hippopotamus amphibius*), clawless otter (*Aonyx capensis*), and spotted-necked otter (*Lutra maculicollis*). However, mammalian populations are presently only a fraction of those existing before intensive hunting which began in the 1930's and continues today by poachers. Elephant (*Loxodonta africana*), waterbuck (*Kobus ellipsiprymnus*), puku (*K. vardoni*), sable (*Hippotragus niger*), hartebeest (*Alcelaphus lichtensteini*), and wart hog (*Phacochoerus aethiopicus*), have been exterminated from the area of Kafue Flats and few large predators remain. The avifauna of Kafue Flats has been listed by Dowsett and deVos (1965), Osborne (1973), and Douthwaite (1977, 1978).

Kafue Flats contains Lochinvar and Blue Lagoon National Parks with a combined area of 840 km² (Fig. 4). Lochinvar National Park is located on the south side of Kafue Flats and provides important crane habitat, including the principal range of the grey crowned crane (*Balearica regularum*) (Robert Douthwaite, pers. comm.). However, the national park status of Lochinvar is threatened by misuse by neighboring fishermen and pastoralists. Fishermen openly use wetlands and roads within the national park, being admitted at the main park gate. Also herds of hundreds of domestic cattle are pastured within Lochinvar, directly competing with resident wildlife.

Fishermen and stockmen should be restricted to areas outside national park boundaries because their presence is not conducive to the proper management of the park and apparently hinders wattled and crowned cranes from nesting in upland marshes as they used to when park regulations were strictly administered (Walkinshaw 1973). Blue Lagoon National Park has been closed to the public in recent years, presumably for

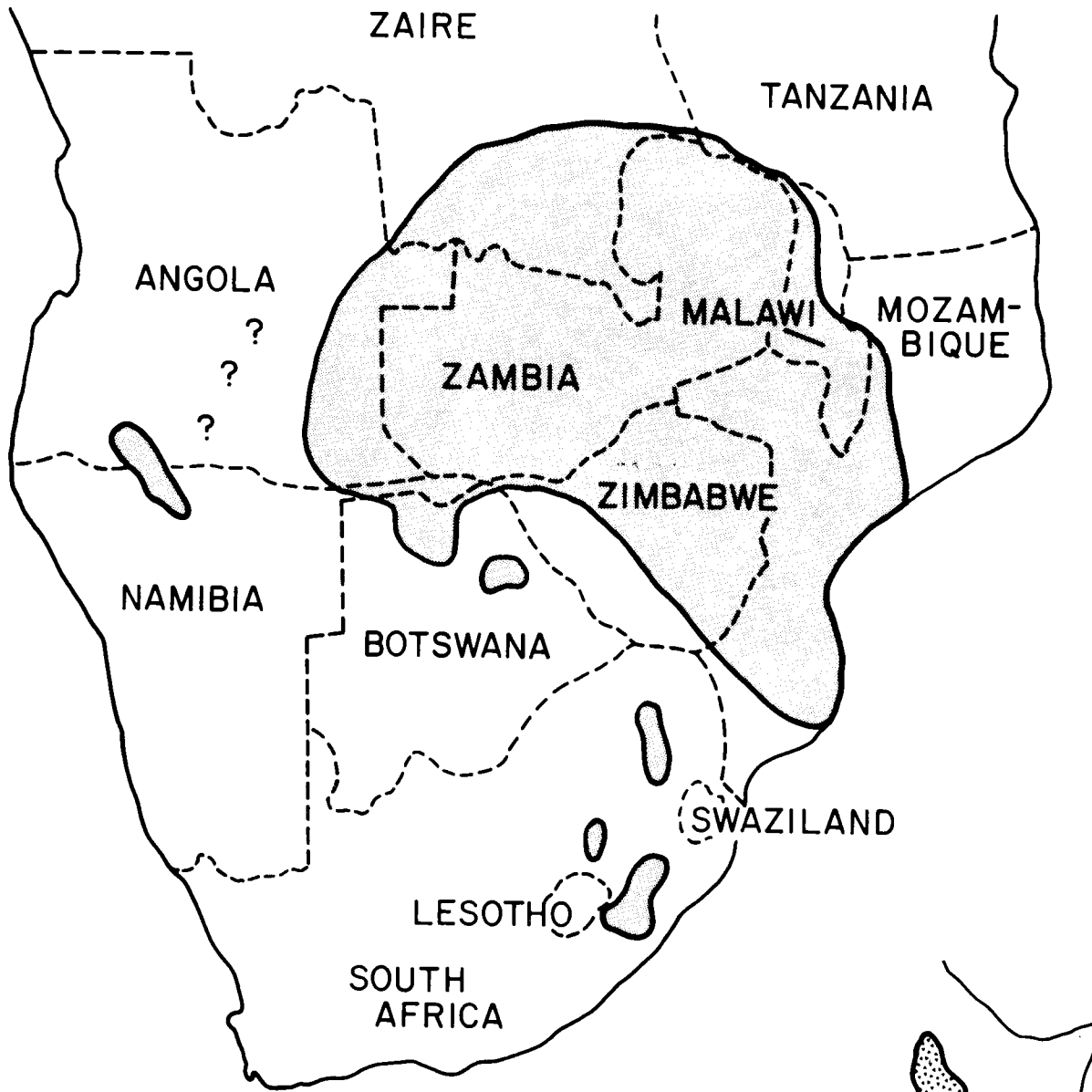
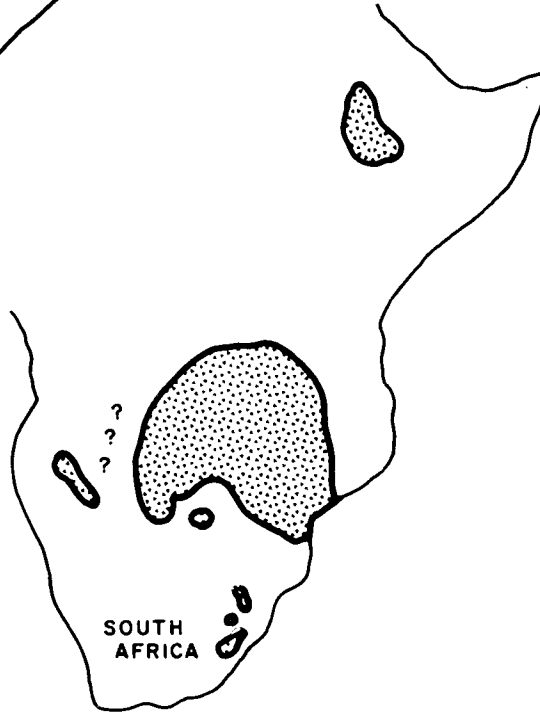


Fig. 2. Distribution of wattled cranes in Africa (lower right), with the more detailed distribution for the southern third of the continent shown above.

security reasons. However, this valuable park should be reopened, especially considering its proximity to Lusaka, Zambia's capital city, and the many citizens who could enjoy viewing the environs and wildlife. These recommendations are reasonable because the national park system on Kafue Flats is a small fraction of the area open to extensive human use.

Kafue Flats has been described as 1 of Africa's greatest wetlands. The great importance of this region to the Zambians is reflected in fishing, agricultural, pastoral, mining, industrial, hydroelectric, national parks, and wildlife interests. With so many separate interests involved in the use of this wetland, Kafue Flats may be the most studied, most developed, and most controversial.



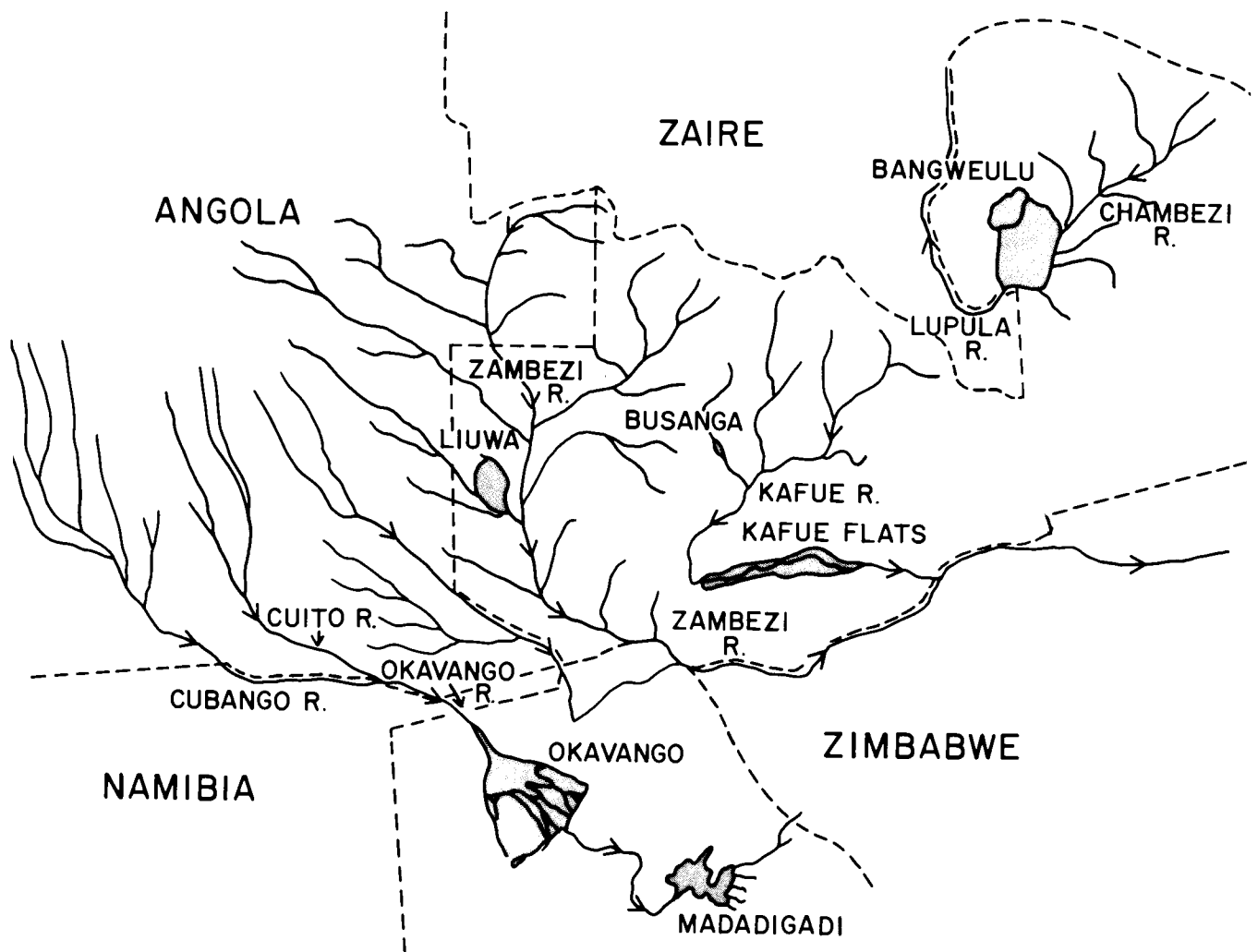


Fig. 3. Major river drainages and the large wetlands.

Table 1. Average rainfall (cm) as recorded at towns near African wetlands important to wattled cranes (see Fig. 6).

Wetland ^a	Monthly rainfall												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	28.8	25.2	18.4	3.9	0.5	0	0	0.1	0.1	1.2	13.0	24.9	116.1
2	21.8	19.6	10.6	2.1	0.4	0	0	0	0	1.5	9.1	18.6	83.7
3	26.2	25.1	25.9	6.9	0.8	0	0	0	0.1	1.7	13.5	23.7	123.9
4	21.7	21.5	15.1	3.8	0.2	0	0	0	0.2	3.5	10.2	22.2	98.4
5	20.3	16.4	23.6	9.0	0.9	0	0	0	1.1	6.7	14.9	19.1	112.0
6	10.4	9.5	8.1	2.5	0.5	0	0	0	0.1	1.7	4.3	8.1	45.2
7	10.2	8.2	6.9	1.7	0.5	0.2	0.1	0.1	0.2	1.9	5.6	9.1	44.7

^aUpper Kafue Basin-Busanga and Kafue Flats (Ndola, Zambia); (2) Kafue Flats (Lusaka, Zambia); (3) Bangweulu (Kasama, Zambia); (4) Liuwa (Mongu, Zambia); (5) Upper Angola Basin-Liuwa and Okavango (Chitembo, Angola); (6) Okavango (Maun, Botswana); and (7) Magadigadi (Francistown, Botswana).

A great controversy began with the initiation of a hydroelectric scheme including construction of a dam at each end of Kafue Flats (Fig. 4). A background history of this hydroelectric development is presented by Williams (1977). Kafue Gorge Dam was completed in 1972, its reservoir flooding the eastern end of the Flats with small effect on the wildlife. However, the recently completed Iteshiteshi Dam located on the upstream (west) end of Kafue Flats may have monumental effects on the wildlife communities, especially those associated with the floodplain on which wattled cranes and Kafue Lechwe are dependent.

Iteshiteshi Dam was built to hold water in its reservoir during the flow of potential floodwaters from the upper Kafue River Basin, and to release waters during the low water period to offset the seasonal discharge variations of the river. Therefore, contrary to the natural flooding regime, streamflow will be reduced during the rainy season and increased during the dry season. This scheme will reduce the area of floodplain by reducing the area of seasonal flooding and by permanently flooding lagoons and low depressions. The vegetation, fish, wildlife, and man have all adapted over centuries to the flooding regime of Kafue Flats; therefore, it is anticipated that the populations of organisms that rely on the floodplain will be reduced in relation to reduction of floodplain area.

The present hydroelectric scheme on Kafue Flats will greatly effect the population size of the wattled crane by restricting the area of the floodplain and consequently constricting the feeding areas, the total wetland habitat, and the nesting territories located within the floodplain. As stated earlier, fewer wattled crane pairs nest with low flooding (Douthwaite 1974). This habitat change presents a serious situation for the future of Africa's largest population of wattled cranes. Perhaps the population size will remain static over several years while reproduction lags, but in a decade the population size will have dropped due to lower recruitment caused by the impact of present Iteshiteshi Dam hydrology policy. This trend is already a factor because only 3.6% of the total population observed on Kafue Flats in 1978-1979 were young of the year.

The fishing industry will be affected by the permanent flooding caused by waters released from Iteshiteshi Reservoir because flooding reduces the available prime fishing areas and affects the spawning of native fishes which is also closely related to the annual flooding cycle. This fishery decline is of great importance to Zambia because Kafue Flats accounts for up to one-quarter of the total annual fish production for a nation dependent on this resource to feed its human population.

Pastoralists will also be affected by Iteshiteshi because their domestic cattle herds are dependent on the vegetation of the dry floodplains. The smaller floodplain area flooded and dried each season will limit the number of cattle below present numbers.

Likewise the upland mammals relying on the dry floodplain vegetation will be affected, namely zebra, wildebeast, roan, buffalo, eland, and reedbuck. The Kafue lechwe are more closely dependent on the floodplains used by the wattled cranes and their population size will also be affected due to the constriction of their floodplain habitat.

The water discharge at Iteshiteshi Dam should not only be dictated by the needs of the hydroelectric

Table 2. Wattled crane census results in selected wetlands of southern Africa, 1978-1979.

Wetland	Number observed	Pairs	Chicks	Nonbreeders
Kafue Flats	552	180	20	172
Bangweulu	20	5	0	10
Busanga	31	14	2	1
Liuwa	145	42	8	53
Okavango	21	9	2	1
Magadigadi	15	4	1	6
Total	784	254	33	249

scheme but also by the needs of the resident people, wildlife, and natural ecology of Kafue Flats ecosystem. Proper regulation and timing of water discharge at Iteshiteshi Dam is most important and can be used to the advantage of all interests. Regulation of this water could enhance the total production of the Kafue Flats--ecologically and industrially. To date no effort has been made to involve all interests in determining the regulation of waters discharged at Iteshiteshi by the Zambian government. Although the Kafue Gorge Power Station can provide all of Zambia's electrical energy, any deficit in electrical output caused by water regulation can easily be made up through Kariba Dam's Power Corporation, which includes Zambia.

I hope that the special interests within Zambia's Ministry of Power, Transport, and Communication; Ministry of Lands and Natural Resources; Ministry of Agriculture and Water Development; Ministry of Tourism; the Zambia Electricity Supply Corporation; Central Africa Power Corporation; and the Kafue Basin Research Committee, along with international representatives, will join together in a reevaluation of the annual regulation of water discharged from Iteshiteshi Dam for the combined good of all interests. The wattled cranes of Kafue Flats can continue to survive at current population levels with the proper management of this large wetland.

Bangweulu

Bangweulu is a 20,000-km² wetland composed of a lake and adjoining permanent wetland with a seasonal

Table 3. Wattled crane population structure at selected wetlands of southern Africa, 1978-1979.

Wetland	% of population		
	Pairs	Fledged young	Nonbreeders
Kafue Flats	64.2	3.6	32.2
Bangweulu	50.0	0.0	50.0
Busanga	90.3	6.5	3.2
Liuwa	57.9	5.5	36.6
Okavango	85.7	9.5	4.8
Magadigadi	53.3	6.7	40.0
Mean %	64.3	4.2	31.5

Table 4. Wattled crane productivity data for selected wetlands of southern Africa, 1978-1979.

Wetland	% successful breeding pairs	% productivity	Chicks/pair	Pairs/chick
Kafue Flats	11.1	3.6	0.11	9.0
Busanga	14.3	6.5	0.14	7.0
Liuwa	19.0	5.5	0.19	5.2
Okavango	22.2	9.5	0.22	4.5
Magadigadi	25.0	6.7	0.25	4.0
Mean	13.0	4.2	0.13	7.7

flooding regime which pervades all aspects of the ecology and economics of the area. The water level over this wetland varies seasonally between 1 and 2 m causing the floodline to advance and recede by as much as 45 km at the periphery (Grimsdell and Bell 1976; Fig. 5). The 190,000-km² catchment basin receives the highest rainfall in Zambia with the mean annual rainfall measuring up to 160 cm. Most precipitation falls between November and March (Table 1; Fig. 6). Bangweulu is fed by 17 principal rivers, the Chambezi is the largest. The Luapula River, a headwater of the Congo, is the only river draining the Bangweulu.

A water meadow formed along the floodplain is marked by an association of *Cyperus latifolians* with *Eleocharis fistulosa* (Vesey-FitzGerald 1965). This habitat provides feeding areas for both the black lechwe (*Kobus lechwe niger*) and wattled cranes. Although the wattled crane is a well-known resident of Bangweulu, little information about this species has been recorded. Bangweulu's wattled cranes have not been censused, but from earlier observations this population probably numbers several hundred (Brelsford 1947, Mwenya 1973, Grimsdell and van Lavieren in Douthwaite 1974). Most wattled cranes were observed along the southeastern floodplain during a preliminary aerial survey of Bangweulu in October 1978. Considering the low numbers observed during the flight (20), it may be theorized that some movement may take place between Bangweulu and other wetlands (i.e., Kafue Flats), especially because unusually high water levels were present even during the driest period (late Octo-

ber) due to extremely heavy rains earlier in 1978. In the future it will be important to census Bangweulu for wattled cranes throughout the year to gain information on the population status and movements of these cranes.

Bangweulu is an important wetland for wildlife, supporting a diverse fauna including the largest known populations of the endemic black lechwe, the sitatunga (*Tragelaphus spekii*), an antelope restricted a deep wetland (*papyrus*) environ, and the shoebill stork (*Balaeniceps rex*). Large numbers of local and migrant water birds are present in Bangweulu including waders, shorebirds, waterfowl, and many mammals.

Except for a small area included in Isangano National Park, the entire area of Bangweulu is included in game management areas which protect resident wildlife, but allow hunting of predetermined numbers of certain species by permits issued by the National Parks and Wildlife Service. Most wildlife exist below the carrying capacity of the region due to previous indiscriminate hunting and poaching. This is notably seen in the black lechwe population which was thought to be greater than 200,000 before 1936 and was reduced to about 16,000 by 1969, though it numbers over 30,000 today (Bell and Grimsdell 1973).

Bangweulu supports 1 of Zambia's largest fishing industries with small fishing villages and camps scattered along the wetlands perimeter and islands. Currently Zambia is building a road which will bisect the

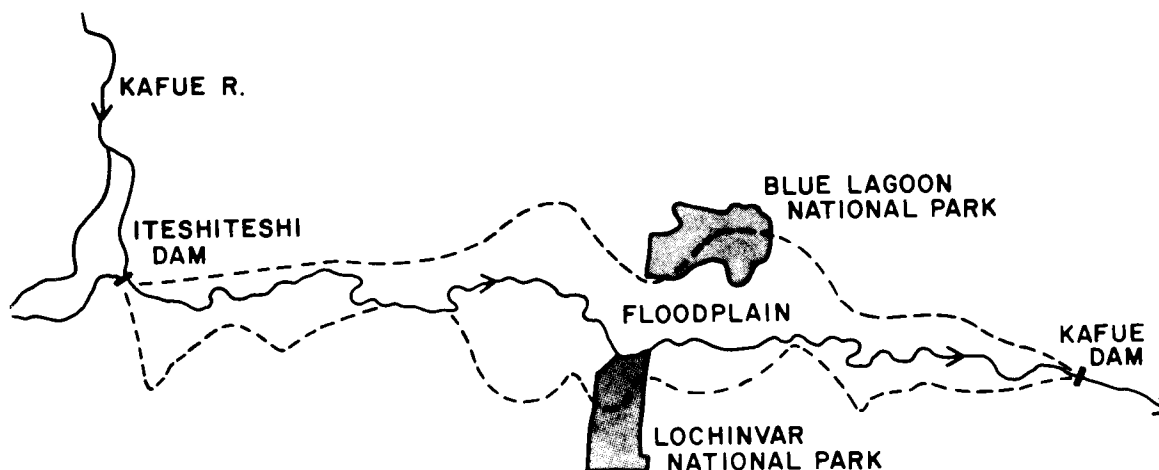


Fig. 4. Bangweulu (20,000 km²) with its associated wetland and floodplain.

southwestern floodplain of Bangweulu. It is unfortunate that this highway could not skirt the side of Bangweulu to avoid disrupting the floodplain of this wetland and dealing with the added problems of supporting a road on the unstable footing of the wetland substrate. The planning and construction of this road must be questioned; however, if proper drainage is provided under the roadway, the ecology of Bangweulu should not be appreciably harmed and the road will provide easier access to this wetland.

Other long-range developments have been proposed including a major hydroelectric scheme involving 2 dams on the Lauapula River with the Bangweulu basically acting as a reservoir (Grimsdell and Bell 1976). This project would have disastrous effects on the ecology of Bangweulu and its wildlife populations. A channelization project has also been proposed which would enable easier water transportation through the wetland (Gilson Kaweche, pers. comm.). The rational use of Bangweulu's resources must be wisely considered when development projects are planned so the development enhances the total area rather than downgrading the whole or parts of it.

Busanga

Busanga is a permanent wetland encompassing about 400 km² in the upper Kafue Basin and is drained to the south by the Lafupa River, a tributary of the Kafue River. A floodplain is formed as a perimeter around Busanga and extends to the south along the Lafupa's drainage (Fig. 7). Floodwaters rise throughout the rainy season (November through March) and continue through May when they begin to recede.

As floodwaters recede, wattled cranes begin nesting in June and July over large open expanses of shallow floodplain. Pairs of wattled cranes also nest in outlying seasonal wetlands (some located 30 km from Busanga), but rely on Busanga during the dry season (John Hazam, pers. comm.). In late October 1978, Busanga's floodplain was very dry with pairs of wattled and crowned cranes on territories centering around small wetlands formed along dry drainage channels and the permanent wetland border. The behavior of wattled cranes during the high flood period has not been documented at Busanga; however, because little habitat remains due to high water levels, these birds are very likely to disperse to surrounding wetlands or concentration areas such as Kafue Flats or Magadigadi. The wattled crane population in Busanga was censused 4 times in 1971-1972 by Logsden and van Lavieren during lechwe surveys and was estimated to number between 145 and 328 birds (Douthwaite 1974).

Large numbers of local and migrant waterfowl use this wetland during the floods and when waters recede the plain becomes host to many birds, including yellow-billed storks (*Mycteria ibis*), saddlebill storks (*Ephippiorhynchus senegalensis*), openbill storks (*Anastomus lamelligerus lamelligerus*), spur-winged geese (*Plectropterus gambensis*), Senegal wattled plovers (*Xiphidiopterus senegallus lateralis*), and African fish eagles (*Haliaeetus vocifer*), along with a variety of other fauna. Hippo, sitatunga, and Nile crocodiles (*Crocodilus niloticus*) inhabit the permanent wetland while zebra, wildebeast, and puku graze the greened floodplain during the dry season.

Busanga presently has a resident red lechwe (*Kobus lechwe lechwe*) population of approximately 3,000, which has increased steadily since a low point in 1946, and supports 1 of Africa's largest buffalo herds, numbering over 2,000. Nearly all of Busanga's wetland area

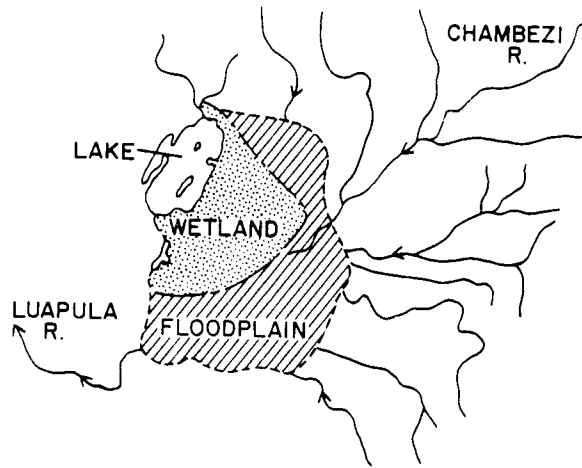


Fig. 5. Bangweulu (20,000 km²) with its associated wetland and floodplain.

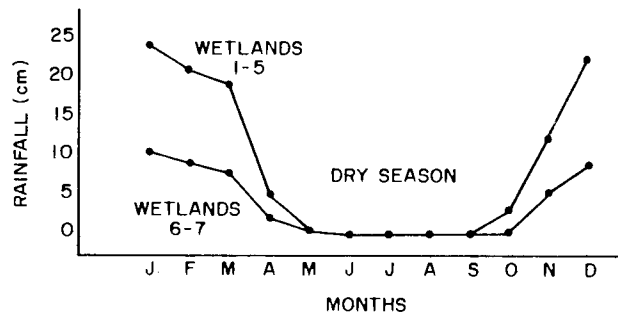


Fig. 6. Average rainfall at towns near African wetlands important to wattled cranes (see footnote of Table 1 for key to wetland numbers).

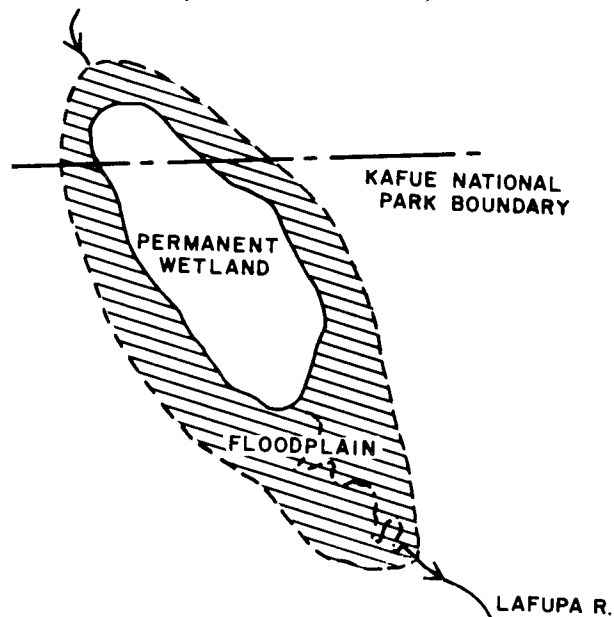


Fig. 7. Busanga (400 km²) and the associated floodplain.

is protected as a natural wildlife preserve within Kafue National Park (Fig. 7); consequently, this wetland and its wattled cranes are well protected for the future.

Liuwa

Liuwa is a 3,500-km² floodplain formed in the upper Zambezi River Basin between the Luanginga and Luambimba Rivers. Mundi Stream, a tributary of the Luambimba River, follows a course through the center of Liuwa, and is instrumental in the flooding and drainage of most of the floodplain (Fig. 8). Floodwaters occur in December as a consequence of rainfall locally and in eastern Angola (Table 1). Rains cover the large floodplain with 1-2 m of water due to the low, flat terrain and a high watertable. Draining by June, Liuwa is a broad, flat plain with scattered small wetlands and limited woodlands along slightly elevated ridges.

Wattled cranes are abundant in Liuwa and may number over 500. Most nesting takes place in June, July, and August in the scattered small wetlands which may be 1 ha after floodwaters recede. Some nesting also occurs along flooded stream borders. During a census of selected areas of Liuwa in November 1978, 145 wattled cranes were observed (58% were paired). Only 8 of the pairs were successful in raising a chick to fledging (Tables 2, 3, and 4). The Liuwa is important to wattled cranes because it represents the largest population and habitat area under total protection within Liuwa Plain National Park. However, this protection is superficial and in fact during the nesting season the wattled crane is under pressure from fishermen who rob the nests of their eggs, disturb the nesting pair enough to cause failure of the nest, or capture unfledged chicks (Pete Conant, pers. comm.). This is a serious problem to the crane population in Liuwa.

Liuwa also provides prime habitat for crowned cranes which were observed to be 6 times more populous than wattled cranes in the areas censused (836 total) and can be observed in large flocks in the dry season, some numbering from 100 to 400 birds. Crowned crane abundance is due to their more upland habits and the extensive, undisturbed breeding areas during the rainy season (high floodwaters prevent disturbance by fishermen). Their reproductive rates are also higher with 2 or 3 chicks often raised.

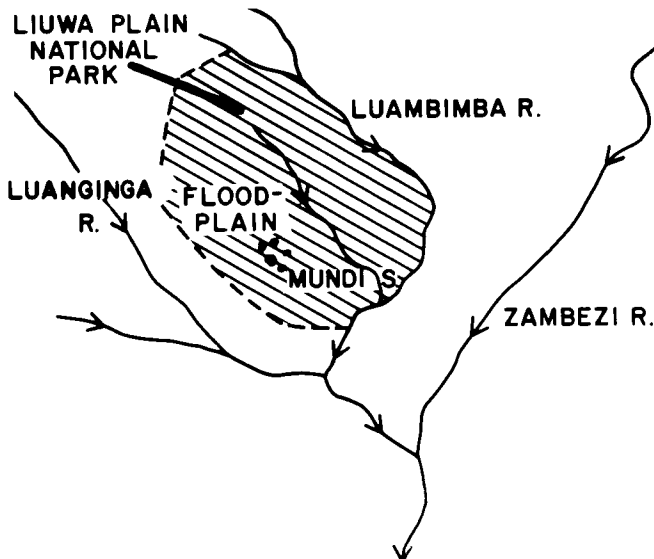


Fig. 8. Liuwa (3,500 m²) wetland.

Today Liuwa remains a wild and remote region supporting a diverse and plentiful wildlife community. Liuwa is totally dominated by the huge wildebeast herds, perhaps numbering 40,000 while zebra, red lechwe, oribi (*Ourebia ourebi*), and tsetsebe (*Damaliscus lunatus*) make up the principal big game populations with lions (*Panthera leo*) the most numerous large predators. The region is also important to local and migrant waterfowl and shorebirds along with bustards and birds of prey. This wetland is aptly included in Liuwa Plain National Park (3,660 km²).

Liuwa has long been controlled by the resident Lozi people of Zambia. Liuwa's significance to the wildlife of the region was realized long ago and the Paramount Chief or Litunga of the Lozi people made the Liuwa a game reserve nearly 300 years ago. This tribal protection continued until 1972 when Liuwa Plain National Park was established by the Zambian Government. However, Liuwa now has a great human problem. Although the Litunga refused to disturb the animals, prohibited hunting, and, at least originally, did not allow settlement in Liuwa, about a century ago a few hunting camps became established. These camps became small villages over the years. Today about 1,000 people live inside Liuwa Plain National Park and exploit the natural resources through fishing, poaching, growing casava, and grazing thousands of domestic cattle (Pete Conant, pers. comm.), all to the detriment of national park interests and against government established laws.

A solution to this problem would include the relocation of the villages located within park boundaries; however, these people prefer living in the park. An alternative solution might include relocation of national park boundaries. Most villages are located inside the south and east borders of Liuwa Plain National Park; consequently, a shift of the boundaries to the north and west would exclude most villages and people and include in the national park open lands toward Angola. Any villages then remaining inside the new park boundaries could be relocated (Pete Conant, pers. comm.). Liuwa Plain National Park must then be administered as a national park in the strictest sense, eliminating all fishing, poaching, livestock herding, and all other illegal forms of trespass. An educational program should be initiated to instruct the neighboring people about the importance of Liuwa to wildlife populations and the legalities of a national park--that wild animals do not constitute food, but their own cattle herds do. This transition will take time, but is of paramount importance to the future of the Liuwa Plain National Park and its wildlife.

Okavango

The Okavango of northwestern Botswana consists of a permanent wetland, seasonally flooded lowlands with dry woodland-grassland islands, and adjoining savannas within a 13,000-km² area. It is a mosaic of habitats and forms the world's largest inland river delta. The major river channels of the Okavango, including the Thaoge, Matsebe, Xudum, Boro, Santantadibe, Kawi, and Thamalakane, are relatively narrow and shallow but meander within broad floodplains and with slight increases in water level inundate large areas (Fig. 9). The source of water for the Okavango begins in the Central Highlands of Angola where the Cubango and Cuito Rivers transport water to the Okavango River which follows a southeastern course to the Delta (Fig. 3).

Water levels of the Okavango are dependent upon the rainfall in the headwater basins of the Angola high-

lands where heavy rains occur from November through April (Table 1). High water levels usually reach the upper Okavango in March, but do not reach their maximum throughout Okavango until June or July. Receding floodwaters reach a low in January when local rainfall (November through March) adds to the waters; however, the rains and flooding cycle of the Okavango are subject to annual variations in timing and volume.

Wattled cranes inhabit the shallow southern border of the permanent wetland and the floodplains of the numerous river courses. Feeding on the usual sedges, the wattled cranes nest as floodwaters recede in August and September. The United Nations Development Program ecologists, in cooperation with the Botswana Department of Wildlife, National Parks, and Tourism, conducted aerial surveys of the principal wildlife populations in the Okavango, including 1 census of wattled cranes in February 1977 using a systematic method of transect sampling (Astle and Graham 1976). The results of this survey have not been analyzed for wattled cranes (Douglas Williamson, pers. comm.) although this population may number over 1,000.

Based on information gathered during a February 1979 survey of western Okavango, when 9 pairs (2 with fledged chicks) and 1 single wattled crane was observed, I suggest that October may be a better month to census wattled cranes. By October, floodwaters have drained to provide large open floodplains for feeding wattled cranes, but by January and February many cranes appear to leave due to dry conditions, perhaps moving to the Magadigadi Pans to join migrant concentrations there.

Thousands of large mammals rely on the extensive and varied habitats of the Okavango, including impala (*Aephyceras melampus*), baboons (*Papio ursinus*), red lechwe, buffalo, zebra, tsetsebe, wildebeest, bushbuck (*Tragelaphus scriptus*), kudu (*Tragelaphus strepsiceros*), giraffe (*Giraffe camelopardalis*), sitatunga, wart hog, and elephants, along with over 400 species of birds. The Moremi Wildlife Reserve is located in the northeastern section (Fig. 9) and includes all the major habitats of the Okavango with the exception of papyrus swamp (Astle and Graham 1976).

Today the Okavango remains a wild, natural area inhabited by a colorful biota living in pristine conditions. Man has not penetrated this wetland for any length of time and even today is limited to small villages along the edges of the Delta. However, since most of Botswana consists of the dry sands and low bush of the Kalahari Desert, the waters of the Okavango are of great interest for future development. To date the savior of this wild region has been the seemingly insignificant tsetse fly (*Glossina morsitans*) which passes the dread sleeping sickness by the transfer of parasitic trypanosomes from host species of game animals and has long kept man and his domestic livestock from the Okavango.

In an effort of wetland reclamation the government of Botswana has long been involved in programs for the eradication of the tsetse fly, beginning in early days with game destruction and bush clearing, and even eventually leading to large-scale ground applications of Dieldrin and DDT from 1967 through 1976. The use of diluted solutions applied selectively to specific vegetation sites helped reduce the negative effects of these persistent insects. Since 1973 a program of aerial spraying of Endosulphan has been applied in specific "blocks" in which 6 applications are made over 100 days. Endosulphan has important differences from previously used insecticides; it has a relatively

low persistence but a higher toxicity to fishes than to tsetse flies, which may be harmful to the fishing industry due to the nonspecific applications via aerial spraying (Russell-Smith 1976).

The tsetse fly eradication program is designed to open areas of the Okavango to human use of pastoral, agricultural, and mining interests. When flying over interior Okavango, abundant wildlife is seen in quiet seclusion but along the edge of the Delta, where man now lives in small numbers with his herds of cattle, goats, and donkeys, little wildlife is observed. In disturbed areas waterfowl, egrets, herons, marabou storks (*Leptoptilos crumeniferous*), and openbill storks are observed but the large mammals and shy birds, including the wattled cranes and saddlebill storks, are absent. As the Okavango is opened for human use it can be predicted that the wildlife will be replaced by the herds of domestic livestock and people now limited to the border, and that the forested areas will be cleared and plowed for agricultural purposes to further scar the natural beauty of this unique wetland.

Botswana's government has made apparent its concern for sensible development of the Okavango by sponsoring a "Symposium on the Okavango Delta" in 1976 when people representing a wide variety of interests and concerns gathered to discuss the future of this great wetland. It is hoped the resulting information will provide a basis for intelligent and restrained use of this valuable resource.

Magadigadi

In the northeastern expanse of the Kalahari Desert a flat, ancient lake bed evolved into a unique wetland consisting of 2 large alkaline salt pans with many smaller alkaline wetlands along their bleached white borders, all collectively known as the Magadigadi (or Makgadikgadi, Mahgadihgadi, or Makarikari). The Botleteti River, draining from the Okavango, enters the southwestern corner of Mtwetwe Pan, which is linked to Soa Pan, although the latter is mainly fed by the Nata, Semowane, Mosetse, Lapashe, and Mosupa Rivers draining from the east (Fig. 10). The Magadigadi

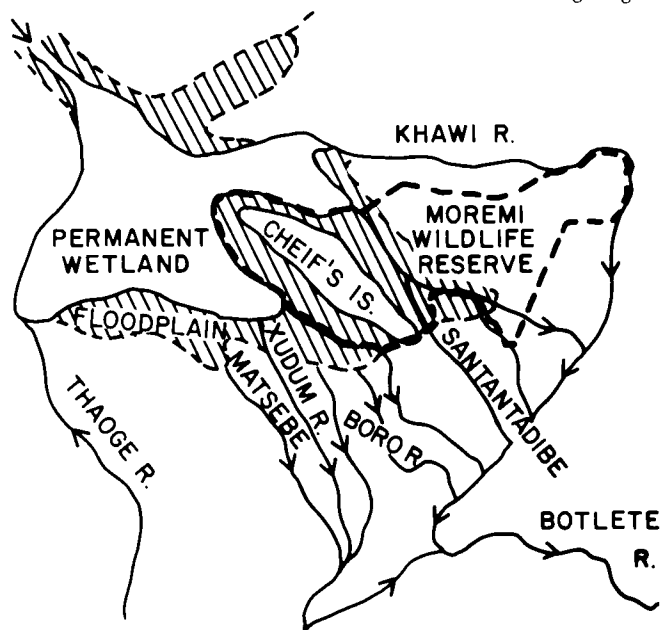


Fig. 9. Okavango (13,000 m²) and Moremi Wildlife Reserve.

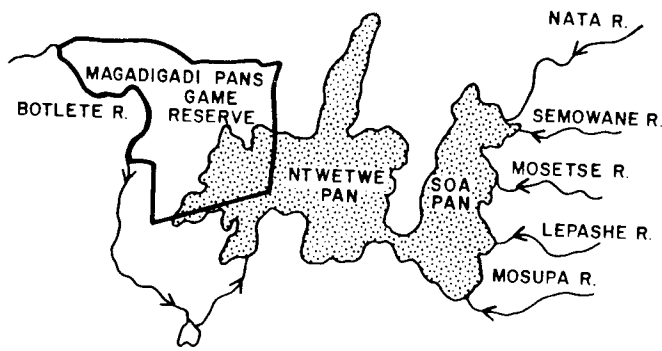


Fig. 10. Magadigadi Pans, including Ntwetwe Pan, Soa Pan, and Magadigadi Pans Game Reserve.

dries totally most years except at the Botletli River inlet, but fills with a shallow sheet of water from local rains which fall from November to March (Table 1). The Magadigadi and its associated plains are a vast, wild, and virtually uninhabited region of Botswana.

Unlike the other large wetlands described in this paper the wattled crane is known only as a migrant to the Magadigadi during the wet season. Migrant wattled cranes are present from January to May and may number from several hundred up to 2,000 in a given year (Mark Muller, pers. comm.). The origin of these flocks is thought to be Kafue Flats in Zambia, which wattled cranes are known to leave during the periods of high flooding (Douthwaite 1974). Although this movement has not been confirmed, it is the most likely theory at this time. There may also be some migrant recruitment from the Okavango. These movements should be documented by marking birds with color-coded, numbered bands or radio-tags. During their stay at Magadigadi the wattled cranes feed on *Cyperus* tubers (Smithers in West 1977) on the rain-moistened uplands and roost in small rain-filled pans. Many of the wattled cranes migrating to the Magadigadi moult during their stay, becoming totally flightless at times (Mark Muller, pers. comm.).

During a 1 February 1979 aerial survey of Ntwetwe Pan only 15 wattled cranes were observed, in the small pans near the northwestern border of Ntwetwe. However, about 400 wattled cranes were observed in the area north of Soa Pan (Robert Douthwaite, pers. comm.).

The biology of the wattled cranes concentrating in the Magadigadi has not been studied and future research should identify wetland and upland habitat use, movements within this wetland, and feeding behavior. Perhaps most important is an annual census of the Magadigadi during peak populations, perhaps the end of March or early April, which coincides with seasonal use of this wetland by other migrant and wet season residents. The Botswana Department of Wildlife, National Parks, and Tourism is best suited to perform this annual survey and would benefit by this information gathered for future management of the Magadigadi.

Each year 6 to 12 wattled cranes are captured from clocks in the Magadigadi for export to zoological parks by Birds and Game Botswana Ltd. under license issued annually by the Botswana Department of Wild-

life, National Parks, and Tourism (unpubl. dep. records). These birds add to captive breeding programs and make it possible for zoo visitors to see these impressive birds. However, this practice should not be expanded or developed elsewhere.

Other migrant wildlife also rely on the Magadigadi when water is present. With game trails etched in the Kalahari sands to show their passing, huge herds of zebra, wildebeest, tsetsebe, gemsbok (*Oryx gazzella*), and springbok (*Antidorcus marsupialis*) seek out the water of the Magadigadi, especially in the northwestern regions. Most of these herds are migratory and follow an annual cycle through much of northern Botswana. Also present during the rains are flocks of red-billed teal (*Anas erythrorhynchos*), spur-winged geese, yellow-billed storks, saddlebill storks, white pelicans (*Pelecanus onocrotalus*), pink-backed pelicans (*Pelecanus rufescens*), lesser flamingos (*Phoeniconaias minor*), and greater flamingos (*Phoenicopterus ruber roseus*), with the latter 2 species nesting and raising young in the Magadigadi's brackish waters in some years. Ostrich (*Struthio camelus*), black-bellied korrhaan (*Eupodotis melanogaster*), and secretary birds (*Sagittarius serpentarius*) are resident on the plains areas along with some herd animals, especially gemsbok. The northwestern portion of Ntwetwe Pan, and a larger area of the plain including many scattered small pans near Ntwetwe's edge, are included in the Magadigadi Pans Game Reserve (Fig. 10).

SMALL WETLANDS

Throughout their range wattled cranes feed, roost, and nest in scattered small wetlands. These small wetlands can be classified as ephemeral, seasonal, semipermanent, and permanent, and are contained in basins or areas of low gradient along streams or small rivers. Each wetland forms wet meadow and shallow marsh zones and is typically surrounded by level or slightly sloping grassland. In small wetland habitats, wattled cranes are widely scattered with 1 pair inhabiting a single wetland, although more than 1 pair or small groups of nonbreeders may be found in some wetlands.

The small wetland habitats may be divided into 2 subtypes: those found in (1) relatively level lowlands, and (2) hilly highlands. The highland habitats are limited to the edges of the Drakensburg Mountains in Natal and Transvaal, South Africa, highlands along the Zimbabwe-Mozambique border, the plateaus of Malawi and extreme eastern Zambia, the highlands of southwest Ethiopia, and perhaps areas in the Angola Highlands. Lowland wetlands are found elsewhere throughout the wattled crane's range.

Wattled crane pairs tend to be sedentary on their small wetland nesting territories (Warwick Tarboton, pers. comm.). Their nesting period varies throughout the year and is dependent on seasonal and annual water levels, and the water regime of individual wetlands. Nesting appears to peak in December, coinciding with seasonal precipitation and corresponding high water levels in the small wetlands (Walkinshaw 1965, Warwick Tarboton 1981, Robert Dowsett, pers. comm.). However, the reverse is true for Ethiopia (northern hemisphere), where wattled cranes nest mainly from May through August (Mackworth-Praed and Grant 1952), after the "small" and "big" rains from June and September, and before the dry season which runs from October through December (Urban 1974).

The small wetlands make up an important portion of the total habitat available to wattled cranes. How-

ever, the small wetland habitats are more easily disrupted by draining, filling, damming, afforestation, human habitation, and degrading agricultural practices. These developments have led to a decline in numbers of wattled cranes and a decline in the geographical range of the species.

In its southernmost range the wattled crane is becoming increasingly rare and has been extirpated from former range in Swaziland (Ted Reilly, pers. comm.) and in Cape Province, South Africa, where it was formerly widespread (West 1976, 1977). The wattled crane is listed as an endangered species elsewhere in South Africa (Siegfried et al. 1976).

The Transvaal Nature Conservation Division, South Africa, is concerned about the small remaining wattled crane population found in the Transvaal Highlands. Tarboton (1981) is presently collecting distribution, nesting, and production information and indicates that the total wattled crane population probably does not exceed 25 pairs in Transvaal. He lists close human habitation and increasing activities of trout fishermen as indirect causes of nesting losses, while afforestation by local plantations has been the direct cause of the loss of nesting sites. Tarboton predicts the continuation of present development in this region of Transvaal will cause the disappearance of this population and recommends a halt to development in this region. Ideally the area may be preserved in a mountain grassland reserve.

There is also concern about the steady reduction in numbers of wattled cranes in Natal, South Africa. Jack Vincent and William Barnes (pers. comm.), discussing the steady loss of habitat caused by ever-increasing human development, described several nesting pairs that have abandoned historic territories over the last 20 years. The southern African Ornithological Society's Crane Study Group is gathering information on the current distribution and population status of wattled cranes in South Africa. Initial records indicate the Natal population may be 40 breeding pairs (Deryck Day, pers. comm.). The Natal Parks Board is also interested in conservating wattled cranes, with William Barnes recently starting a 3-year study of the 3 crane species native to Natal. I hope the 2 groups will cooperate in preserving the remaining wattled crane habitat to abate the population decline.

In the Orange Free State, South Africa, 2 wattled crane pairs are known to exist, representing an extremely low remnant population (Deryck Day, pers. comm.).

To the north the present distribution and population size of wattled cranes has not been assessed in their small wetland habitats. Their biology and behavior have received little attention. Therefore, a short statement of current knowledge, within each nation included in the wattled crane's distribution, must suffice at present.

In Zimbabwe (formerly Rhodesia) the northeastern high plateau (Mashonaland) and the eastern edge bordering Mozambique are the principal range of wattled cranes. The Zimbabwe Ornithological Society recently initiated a "selected species survey project", that includes the wattled and grey crowned cranes, which will provide valuable information on the status of these cranes (O. West, pers. comm.). West (1977) indicates afforestation is reducing available habitats.

Malawi's highland plateaus host resident wattled cranes, although this population may also be endan-

gered due to human population densities and the continued afforestation of plateau grasslands (West 1977). A program for providing additional habitat should be initiated to add to wetlands already preserved by Malawi's National Park systems.

Mozambique may host a number of wattled cranes in highland plateaus which continue from Malawi and Zimbabwe and in lowland wetlands, but nesting has not been confirmed and other information is sparse.

In Zambia and northern Botswana individual pairs of wattled cranes reside and nest in scattered small wetlands, perhaps more extensively than presently known. The association and movements of these birds between local small wetlands, and the region's large wetlands, are of considerable interest for the future conservation of this species.

In Namibia (formerly South West Africa) wattled cranes occur in extreme northern wetlands and are believed to be decreasing due to human population pressures (West 1977).

The range of wattled cranes in Angola has not been well documented. However, the wetlands formed along tributaries of the Zambeze River in eastern Angola, along with the wetlands bordering Namibia in the south, and the central highland and basins, may support a significant population.

Zaire represents a borderline range for the wattled crane although the southeastern corner of this nation may contain some, especially in the area of Upemba Basin.

The northern population of wattled cranes is found within the borders of Ethiopia (Fig. 2). Urban and Walkinshaw (1967) summarize all information about this separate population and, although the distribution of these birds is well defined, the population size and breeding biology have not been studied. There may also be a possibility of this population forming a separate subspecies due to its long separation from the southern population. Future studies should include a behavioral study for ethological comparisons. This Ethiopian population should be of special interest to the national government and the Ethiopian Wildlife Conservation and Development Department.

I hope that respective government wildlife departments, conservation groups, and ornithologists throughout the wattled crane's distribution will begin to census them in their respective countries as was done in Transvaal, South Africa, to record wetlands used as nesting, feeding, and roosting sites and describe their ecology qualitatively, and to seek the preservation of these wetlands and their surrounding uplands through the benevolence of landowners or by leasing or total protection of the area as a crane park or wetland refuge. The conservation strategy for the wattled crane should include a satellite network of small wetlands throughout their distribution paralleling the United States' network of Waterfowl Production Areas. This conservation effort will ultimately depend on international concern and cooperation.

FEEDING

The procurement of food takes up the greater part of each day for a wattled crane. The foremost method of feeding is by digging; probing the wet substrate or loosely packed drier soils with its long, gradually tapering bill which is well adapted for this mode of feeding. The nutritious tubers and rhizomes of *Cyper-*

us and *Eleocharis* sedges and waterlilies (*Nymphaea* spp.) are the most commonly eaten foods obtained by digging (Douthwaite 1974, West 1976).

When a food source is located the crane begins digging, rapidly jerking its head, neck, and bill up and down, loosening the soil and procuring entire tubers or parts. The food is swallowed with a quick forward movement of the head which is barely differentiated from the continuous digging movements. At times the digging becomes so involved that the whole body moves, slightly pivoting vertically on the hock joints of the legs, while the dangling wattles flail wildly about as the crane digs furiously for its food. Most of the foodstuff is found by tactile location. Most digging is done in areas covered with variable depths of shallow water.

Wattled cranes dig on the uplands after local rain has softened soils, in areas of loosely packed soil, or along the water's edge. More often these cranes are found digging in shallow water with only their bills submerged, but also feed in deeper water emerging the head, and may even wade into water to the level of the feathered tarsus, submerging the entire head and neck under the water. When the wattled crane submerges its head it must keep a rhythm of breathing, lifting its head periodically for a breath and to look about quickly before underwater digging is resumed. Only rarely did a bird feeding in this manner uproot a full-sized plant rather than just the tuber or rhizome foodstuffs. Table 5 presents the frequency of use of each feeding method as well as use of 3 feeding habitats.

Pecking is another means of foraging by the wattled crane. The bird pecks deliberately at a food item, such as an *Orthoptera* or *Coleoptera* insect, or seeds scattered on the ground. Sand and gravel particles are also eaten in this manner for use in digestion. Pecking usually occurs in the upland, but is also observed on the water's surface or atop matted aquatic vegetation.

The stripping of grass seed heads is mentioned by Douthwaite (1974) on the Kafue Flats. Although I did not observe wattled cranes feeding in this manner,

Table 5. Behavior and habitat utilized by 748 wattled cranes in 772 feeding activities.

Feeding method	Birds observed	%
Digging	760	98.4
Pecking	8	1.0
Picking up snail	1	0.1
Seedhead stripping	0	tr.
Feeding habitat		
Shallow water ^a	668	86.5
Deep water ^b	22	2.8
Uplands	82	10.6

^aOnly bill submersed.

^bHead and, sometimes, neck submersed.

grey crowned cranes and Stanley cranes (*Anthropoides paradisea*) often used this technique when feeding. The bird grasps the grass stem below the seed head, stripping the seeds with 1 upward movement of the head. I observed flocks of crowned cranes moving through a stand of grasses stripping seed heads--all bobbing their heads up and down with stripping motions while walking along as a group, a most comical scene.

I observed a wattled crane twice pick up a large water snail in its bill without attempting to ingest it. However, Douthwaite (1974) describes mollusk shell fragments found in wattled crane excreta, so it is apparent snails are used as a food source at times.

Observations of 772 feeding bouts of 769 wattled cranes in the large wetlands of Zambia show that over 98% of all foraging involves digging, 1.5% pecking, and a single attempt at snail predation. These observations are somewhat biased due to presumed seasonal changes in feeding behavior, lack of observations during all seasons, and the differences observed in individual wetlands. However, the most important observation is that most food is obtained by digging.

REPRODUCTION

The nesting strategies and habitats of wattled cranes have been described within large and small wetlands. Walkinshaw (1973) and West (1963) describe the life history of this crane; life history information about wattled crane population dynamics will now be described.

Cranes typically mature in their 3rd or 4th year and at that time choose a mate, forming a strong pair bond which normally lasts throughout the lifetime of the pair. Nesting pairs are strongly territorial and may defend a nesting territory over 1 km². In small wetlands a single pair may occupy the total area of the wetland. Large expanses of shallow water away from human disturbances are required by the many nesting pairs resident in the large wetlands.

Cranes generally lay a clutch of 2 eggs; however, the wattled crane is the crane most likely to produce a single egg clutch. Among 95 nests (Walkinshaw [1973] for 90 and pers. comm. from Pete Conant and Imanda Illumbella for the remainder) the mean clutch size was only 1.6 eggs. Forty percent of the nests contained a single egg. The chances of finding an incomplete clutch are very slim, because the 2nd egg is laid within 18 hours of the 1st, making the above clutch sizes virtually unbiased.

Productivity is further reduced by pairs that do not nest annually (Douthwaite 1974, Warwick Tarboton, pers. comm.). This irregularity may be the product of evolving in tropical latitudes where they do not react to the rains and humidity of the wet season, as do the crowned, sarus (*Grus antigone*), and brolga (*G. rubicundus*) cranes, or to the dramatic changes in climate and photoperiod of the temperate latitudes as most crane species. Instead, wattled cranes appear to be opportunists. In the large wetlands nesting occurs as floodwaters recede and is associated with the availability of open floodplain which provides nesting territories and sedge foods (Table 1, Fig. 11). In the small wetlands nesting proceeds when the rains provide adequate water and food sources in the wetland edges and surrounding uplands. Some pairs do not nest when conditions are not optimum.

The production of young is further limited because no wattled crane pair has ever been recorded with 2

chicks. Ila tribesmen on the south Kafue Flats consider the wattled cranes poor parents, well aware that they raise only 1 chick (Robert Dowsett, pers. comm.).

As the wattled crane chick develops the legs and feet grow 1st (which is important so that it can keep up with its parents, and to feed and travel in deeper water). Next the body and body feathers develop, and finally the wings and flight feathers. West (1963) states that fledging occurs at 15 to 18 weeks of age; the chick does not fly until it is 5 months old. This is the longest fledging period required by any crane and places the chick at a disadvantage with local predators (including man), especially since the wetlands are drying out as the chicks near fledging.

The slow productivity of wattled cranes and their need for specialized habitat emphasize the importance of immediate and profound conservation measures. If present populations diminish because of the current and future development of African wetlands, the species will be hard-pressed to make an appreciable recovery.

SOCIAL STRUCTURE AND PRODUCTION

Group size and composition were recorded while observing wattled cranes in the large wetlands. Chicks stay with the adult pair for about their 1st year of life, until the adult pair begins nesting the following year. The immatures band together and feed and roost in selected wetlands away from established territories. At age 3 to 5 years cranes choose a mate and a strong bond, which is usually permanent, is formed between the 2 birds. Three categories are used to describe the social structure: mated pair, nonbreeders, and chicks (Table 2).

An assessment of wattled cranes social structure shows paired birds make up the largest portion of all populations. Any 2 cranes observed together, isolated from other cranes or displaying to each other, were considered to be a mated pair and therefore a potential breeding pair. The percentage of pairs in individual wetland populations varied. In Kafue Flats, Bangweulu, Liuwa, and Magadigadi from 50 to 65% of each population was mated pairs. However, 86 and 90% were pairs in Busanga and Okavango. In the latter 2 wetlands resident pairs presumably remained on their territories throughout the dry season, whereas the nonbreeders probably moved to uncensused areas of food availability, or to concentration areas (i.e., Kafue Flats or Magadigadi).

A successful breeding pair was accompanied by their juvenile chick. Chicks are recognized from the ground and from the air by their totally white head, lighter colored body plumage, and submissive behavior relative to the adult pairs. During this study all large wetlands were visited about 6 months after the main breeding seasons, the chicks having fledged by this time.

Productivity was evaluated by the number of chicks raised to fledging. Between 10 and 25% of all pairs successfully raised a chick beyond fledging, although the average for all large wetlands populations was only 13% (Table 4). Fledged chicks accompanying their parents represented less than 10% of the total population in all the large wetlands, varying from 3.6 to 9.5% (Table 3).

The high percentage of pairs observed on Kafue Flats in relation to the low number of successful breeding pairs is significant and probably reflects

reduced nesting habitat due to the effects of the Ite-shiteshi Dam. Production levels of wattled cranes were low during this study. Although productivity was assessed shortly after the fledging of chicks raised during 1978, actual productivity is evaluated by the number of young that survive to become breeding birds; this is an intangible parameter in the absence of individually identifiable birds. The period after leaving the parent birds and before mating is a period of unknown mortality for immature cranes, but recruitment into the breeding population is obviously lower than reflected by the number of chicks fledged.

Nonbreeders were observed as single birds or in groups of from 3 to 34 adult-plumaged birds. Nonbreeding flocks are principally made up of immature (unmated) cranes between 1 and 4 years old. These flocks may also be joined by some breeding pairs that did not find the various conditions acceptable for nesting or were unsuccessful in a recent nesting attempt. One large flock including nonbreeding pairs was observed on Kafue Flats.

The nonbreeding segment of the large wetland populations was also divided into the same 2 groups of wetlands as occurred in mated pairs. The Busanga and Okavango populations contained only 3 to 5% nonbreeders, while the 4 other wetlands contained from 32 to 50% nonbreeders in each population (Table 3). Nonbreeders are probably a more mobile part of each population, not adhering to any specific territory, area, or wetland.

CENSUS

Initially I planned to make aerial surveys of each large wetland to estimate populations of wattled cranes thereby providing a basis for an assessment of the status of the species. However, internal security problems related to military conflicts with Rhodesia precipitated a ban on all civilian flying and aerial surveys could not be made. Therefore observations and censusing were restricted to the ground and do not indicate accurate population sampling of the large wetlands (Table 2).

An aerial census of wattled cranes in the large wetlands is perhaps the most important need for future research. In some wetlands (i.e., Busanga and Magadigadi) a total count may be possible; however, in the larger wetlands a method of sampling (Jolly 1969, Norton-Griffiths 1975, Caughley 1977) will be required, with population estimates extrapolated from the number of birds observed in the samples. The area surveyed

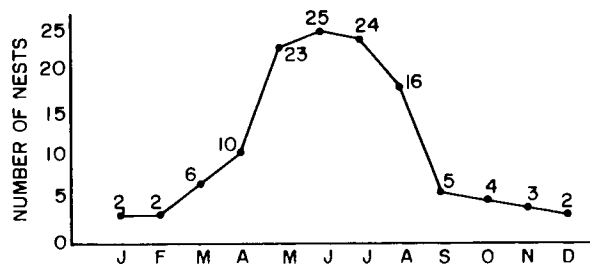


Fig. 11. Wattled crane nesting dates in Zambia based on the following 6 data sources with the number of nests in parentheses: Walkinshaw 1965 (31), Benson et al. 1971 (75), Walkinshaw 1973 (5), Douthwaite 1974 (6), Pete Conant, pers. comm. (3), and Imenda Illumbella, pers. comm. (2).

will be reduced in each wetland because wattled cranes in most instances will be found only in the floodplains. An initial survey should be made of dry season concentrations in each large wetland in an attempt to observe the greatest numbers; however, additional surveys throughout the year will provide interesting information on seasonal use of specific wetlands by wattled cranes as reported by Douthwaite (1974) in Kafue Flats.

Census methods should be selected, carried out, and described in a manner which will allow the uniform duplication of future surveys for true comparisons of data. Kafue Flats, Bangweulu, Busanga, Liuwa, Okavango, and Magadigadi wetlands should be censused initially, with Kafue Flats receiving top priority because population estimates were made before Iteshiteshi Dam by Douthwaite (1974) and insight can be gained into the initial effects the total hydroelectric scheme have had on this population. Two additional large wetlands, namely the Linyanti-Chobi River floodplain which forms a large wetland along the border of Botswana and Namibia before joining the Zambezi River, and the Upemba along the Congo River headwaters in southeastern Zaire, may hold significant numbers of wattled cranes and should also be surveyed (Fig. 12). Aerial censusing is now possible in Zambia with the recent political settlement in Zimbabwe. A concentrated effort should be made to make an aerial census of wattled cranes in these large wetlands.

There is also a need for censusing wattled cranes inhabiting small wetlands throughout their distribution. Each individual nation should make such a con-

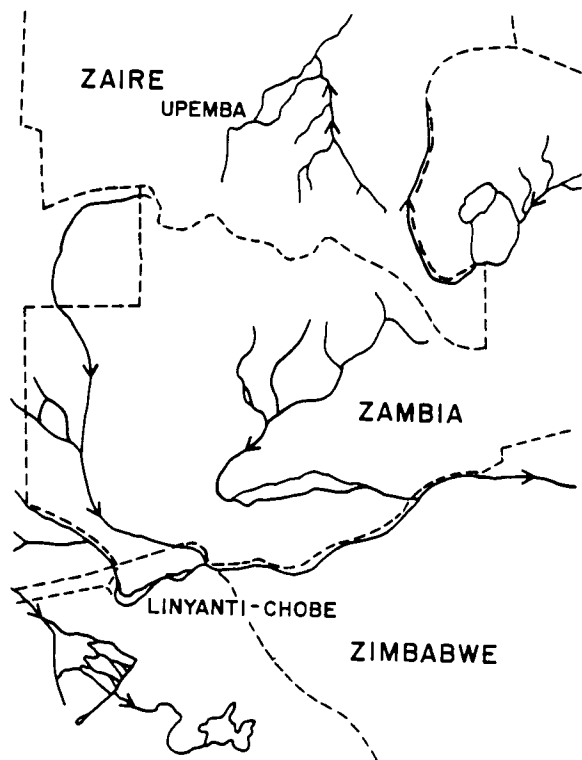


Fig. 12. Upemba wetland in Southeastern Zaire and the Linyanti-Chobe River Floodplain are other wetlands that should be surveyed for wattled cranes.

centrated effort through their respective Wildlife Departments, with the aid of Wildlife Societies, National Park personnel, Ornithological Societies, landowners, and interested individuals. Census of the large wetlands and small wetlands is especially important for the future management of wattled cranes throughout Africa.

MOVEMENTS AND MIGRATION

The movements and migrations of wattled cranes in southcentral Africa are presently a mystery; however, they should be monitored in the future to provide information for management. Marked cranes are necessary to provide insight into the seasonal movements of wattled cranes, requiring the capturing of wild birds and fitting a large plastic, color-coded, numbered band to each. Bands fitting the tibia above the hock joint are considered most appropriate for cranes. The banded wattled cranes would provide information on the movements, territory size, home range, migrations, and life history of individuals of this species; however, the information gained will be limited by the number of observations of banded birds.

An alternative is the use of radio transmitters in combination with the bands. The attached miniature radios transmit signals to portable receivers which aid in the location of radio-tagged birds; however, there are also limitations to the degree of success with these instruments. Present transmitting and receiving equipment have serious distance limitations, short transmitting life, a large size, and would add little to information on migration. I prefer to wait for the more sophisticated solar-powered, ultra-lightweight transmitters which can be tracked by the Nimbus 3 satellite and the location reading relayed to facilities at the National Aeronautics and Space Administration in the United States (Craighead and Dunstan 1976). This equipment should be available soon, allowing the tracking of migrating wattled cranes throughout their total range for a virtually unlimited time throughout the life of these birds. This method will also allow simultaneously monitoring the total radio-tagged population, even with individual cranes in widely separated areas.

It is apparent Kafue Flats and Magadigadi are concentration areas during the dry season and rainy season, respectively. Therefore, these wetlands may be the best areas to begin banding wattled cranes. However, there should be an attempt to band cranes in all large wetlands, especially when the newly designed radio packages are available.

FAUNA ASSOCIATIONS

Studying the ecosystems of the large wetlands presented the opportunity to observe the varied wildlife sharing these areas with the wattled cranes. During these studies a close association was observed between wattled cranes and certain other species, namely, the lechwe, crowned cranes, saddlebill storks, and spur-winged geese.

Lechwe are found in all the large wetlands supporting breeding wattled crane populations (i.e., except Magadigadi). Although there are 3 separate subspecies of lechwe, the red, black, and Kafue, all 3 subspecies utilize the same habitat types and share these with wattled cranes. The lechwe and wattled cranes actually feed on the same plants, the lechwe feeding on the emergent and submerged vegetation and the wattled cranes feeding primarily on the plants' tubers and rhizomes.

Crowned cranes were often observed in association with wattled cranes in Zambian and South African wetlands, although crowned cranes usually prefer a more upland habitat. Their mode of feeding is usually pecking, seed-head stripping, or grazing (as some geese do) rather than the digging typical of wattled cranes.

Saddlebill storks and wattled cranes may share an extensive wetland area or pairs of each species may share a small wetland. Although their similar size enables saddlebills to exploit for food the same wetland habitat as wattled cranes, there is little competition for food between these 2 species, because saddlebill storks have an animal-based rather than vegetarian diet.

Spur-winged geese are often seen inhabiting wetlands with wattled cranes, although they may frequent deeper waters. Douthwaite (1978) describes the seasonal occurrence, distribution, and diet of the spur-winged goose as similar to the wattled crane on Kafue Flats. George Archibald (pers. comm.) observed a similar association between the brolga crane and magpie goose (*Anseranus semipalmata*) in floodplains and domestic sorghum fields in Australia.

ENDANGERED CRANES

Among the 15 species of cranes recognized in the world today, 6 are listed as endangered in the International Union for the Conservation of Nature and Natural Resources *Red Data Book* (Vincent 1966), including the whooping crane (*G. americana*), red-crowned crane (*G. japonensis*), Siberian white crane (*Bugeranus leucogeranus*), black-necked crane (*G. nigricollis*), white-naped crane (*G. vipio*), and hooded crane (*G. monachas*).

The rare Siberian white crane is closely related to the wattled crane (Archibald 1976, Woods 1979), and its winter habitat use and feeding behavior also closely parallel those of the wattled crane. Siberian cranes are very water-oriented birds, deriving most of their food by digging tubers beneath the water's surface. The food of Siberian cranes on their wintering grounds in India are mainly tubers of *Cyperus* and *Eleocharis* sedges (Ron Sauey, pers. comm.), while tubers from sedges of these 2 genera also constitute most of the wattled cranes' diet. The similarities also extend to the percent of young of the year in populations of Siberian cranes, with 8, 9.5 and 7% observed, respectively, by Walkinshaw (1973), Sauey (1976), and Flint and Kistchinski (this Proceedings), which are actually above the percentages I observed in wattled cranes in the large wetlands (Table 3). Although their nesting habitat in the tundra of the Soviet Union is extensive, the riverine floodplains that once supported wintering Siberian cranes in southern Asia have been destroyed and are inhabited by dense human populations, reducing the total population to less than 400 birds. This example should serve to further emphasize the endangered future of the wattled cranes and the importance of habitat protection of this unique African crane.

FUTURE RESEARCH

The future of the wattled crane depends on research to provide information for the development of a comprehensive conservation plan for the continued existence of this species throughout its historic range.

Future research should begin with aerial census of the large wetlands that support large wattled crane

populations, namely, Kafue Flats, Bangweulu, Busanga, Liuwa, Okavango, and Magadigadi. The Linyanti-Chobe and Uempe wetlands should also be considered for aerial census. This census will be a significant study, providing important base-line data on the status of wattled cranes at each large wetland.

Throughout the wattled crane's range there should be an organization of the nations and their respective wildlife departments and societies to collect information on the distribution, population status, wetland use and ecology, and the life history of resident wattled cranes. This research will require participation of many individuals, and the resulting information will be the product of international interest and cooperation.

During the recommended surveys, data should be collected on the social structure of each population, mated pairs, nonbreeding flocks, and successful pairs with their juvenile chick. This data will provide nesting success and production rates. Observations should also be made on feeding methods and the association of each crane with water.

The movements and migrations of wattled cranes should be monitored by banding for individual field identification and eventually by attaching miniature radio transmitters capable of being tracked by satellite. These methods will provide information on movements, territory size, home range, seasonal migrations, and life history.

Wattled crane research is presently in a developmental stage and these recommendations for future research should provide a sound basis to our future understanding and indicate the importance of individual wetlands to this species.

CONSERVATION RECOMMENDATIONS

Wattled cranes live in wetland ecosystems supporting great numbers of divergent species typical of Africa and species unique to a specific locale. Until recent years wattled crane populations have adapted to a specific habitat, and their numbers have been regulated naturally by limiting factors, including available habitat area and food resources. Today man and his technological developments have become limiting factors through destruction and alteration of habitat. If not controlled, these changes may spell the eventual demise of the wattled crane, as has occurred in closely related crane species. In view of the problems facing the wattled crane several recommendations are presented for the conservation of this species and its wetland ecosystems.

The hydroelectric scheme on Kafue Flats should be altered to include optimum regulation of waters for the combined good of all interests, including existing wattled crane and other wildlife populations, the wetland's large fishing industry and pastoralists, and the total ecology of Kafue Flats. This action is of the greatest importance to the wattled crane.

Blue Lagoon National Park in Kafue Flats should be reopened for public use. In Lochinvar National Park, fishermen and pastoralists with their domestic cattle herds should be restricted to areas outside park boundaries because their presence is not conducive to the proper management of the national park and probably hinders nesting of wattled cranes in upland wetlands. The national park system on Kafue Flats is small in comparison to the entire area.

Plans for dams and hydroelectric schemes for Bangweulu should be abated because the Kafue hydroelectric scheme already provides the total power output needed by Zambia, and the Kariba hydroelectric scheme is available to supply any additional power needs.

All humans in Liuwa Plain National Park should be relocated outside national park boundaries or the boundaries should be shifted to exclude all villages. Thereafter, national park authority must be strictly enforced. An educational program should be initiated to teach wildlife and national park values to persons living near the park.

Wetland reclamation and the eventual multipurpose development of the Okavango should proceed with restraint. The wise use of this wetland's natural resources by humans should benefit native wildlife, including wattled cranes. The small wetlands inhabited by wattled cranes should be surveyed and protected throughout the range of the wattled crane.

Reintroduction of wattled cranes should be considered where populations have been extirpated and suitable protected wetland habitats are available.

Many of the world's wildlife species are becoming rare as a result of man's economic growth and technological development, untempered by adequate concern for natural communities and conservation measures. Modern man has a responsibility to act wisely when considering the future of the wattled crane and wetlands that support bountiful life systems making up each wetland ecosystem. These areas are beautiful examples of Africa and should be preserved as areas of international importance for the future of existing wildlife and for all mankind to treasure.

ACKNOWLEDGMENTS

Many people and organizations are acknowledged for their assistance in this project. Most notably, thanks to George Archibald for his inspiration and help throughout this study. Financing and support were furnished by the New York Zoological Society and the International Crane Foundation. The cooperation and interest of the Zambian National Parks and Wildlife Service, the Wildlife Conservation Society of Zambia, the Zambia National Tourist Bureau, the Botswana Department of Wildlife and National Parks, and the Southern Africa Ornithological Society, along with their interest and input, are greatly appreciated. I also thank the following individuals for their personal assistance during this conservation effort: William and Leila Barnes, Susan Colebrook-Robjent, Pete Conant, William Conway, Jean Craker, Deryck Day, Robert and Bridgette Douthwaite, Robert Dowsett, Gerard Ellenbrock, Arthur and Diane Elliot, Joan Fordham, Christo Grobler, Francis Hamill, Sean and Theona Hayden, John Hazam, Geoff Howard, Imenda Illumbella, Gilson Kaweche, Collen and Betty Lindsey, Kathy Lofdahl, Kaimbo Machile, Green Maimbolwa, Stuart Makayi, Mark Muller, Flywell Munyenembe, Borwell Njekwa, Jerry Patterson, Larry Patterson, Francis Phiri, Martin Schofield, Regina Shea, Albert Sitali, Warwick and Guggi Tarboton, Ian Tanner, Tom Taylor, Jack Vincent, Don Yunnai, Geoffrey Zyambo, and Michael, Margaret, and James Wijnberg. My parents, Marvin and Esther Konrad, provided encouragement and support throughout this study and during the preparation of this paper.

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Hooded Crane



Photo by L. Walkinshaw.

THE HOODED CRANE IN THE USSR

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Abstract: *Grus monacha* nests in the USSR on remote, mossy marshes within sparse larch forests, in the middle and partially southern taiga of low mountains (200-700 m above sea level), of the southern Middle Siberian Plateau and the Lower Amur basin. The open swampy lowlands in forest-steppes and steppes of southern Middle and Western Siberia, and also the marshes on the edges of steppe lakes of Southern Transbaikalia (Dauria), are the most important concentration areas of nonbreeders. The main migration route of the Siberian population is the entire Transbaikalia. The cranes inhabiting the area of Priamurye migrate over the Sungari Basin (through Middle Amur Plain) apparently together with birds breeding on Bikin and Khor Rivers.

Until recently the common idea expressed in the literature was that the hooded crane (*Grus monacha*) (Fig. 1) inhabits low-lying marshlands in forest-steppe of southern middle Siberia and marshy lake hollows in steppes of Transbaikalia (Dauria). The idea was based on a few summer observations of cranes but their breeding status in these regions and ages were unknown. It was not until ornithologists found unfledged chicks on taiga marshlands of southwestern Yakutia (Vorobiev 1963, Andreev 1974), and in 1974 in Primorye Territory (Ussuriland) found the 1st nest with eggs (Pukinsky and Ilyinsky 1977), that the previous viewpoint about the nesting range and habitats was proven correct (see Neufeldt 1977, Neufeldt and Wunderlich 1978, Fig. 2).

The scanty data on the nesting of the species indicate that during the nesting season the hooded crane is confined exclusively to remote peat moss swamps within sparse larch (*Larix sibirica*, *L. dahurica*) forests in the middle and partly southern taiga of low mountains (200-700 m above sea level). Within the Soviet Union such habitat exists wherever seasonal or perma-frost develops in mountain depressions in regions of Eastern Siberia and results in the extremely spotty distribution of the hooded crane.

NESTING DISTRIBUTION

The two isolated nesting areas that are known to ornithologists are in the southern Middle Siberian Plateau and the Lower Amur Basin.

Southern Middle Siberian Plateau

Nesting of this crane is confirmed on Olekma-Chara Upland (Fig. 3) in the mouth of the Nizhnee Dzhega and on the Tokko River; it probably also inhabits the Molvo River (Vorobiev 1963). The hooded crane is obviously nesting in Siberia and exceeds in number the common crane (*Grus grus lilfordi*), in the middle and in part of the upper Vilyui River Basin from the mouth of the Appai River and Kuomaryki village (about 117° E longitude), north up to the middle reach of the Posporin River (almost 66° N latitude), and east up to the heads of the Markhara and Ygyatta Rivers at about 115° latitude (Andreev 1974). Nesting has been confirmed on the River Chona (near Tuai Khaya), in basins of the Akhtaranda and Syuldyukar Rivers, and near Vilyuchan village. The most authentic information of the local people comes from Arya, Sokhsoluur, and the middle reach of the Oruktakh River. Mixed-species pairs occasionally form in these places of cohabitation with the common crane. B. N. Andreev reported that such a pair (male *G. grus*, female *G. monacha*) persisted throughout May 1965 near Vilyuchan.

One can safely assume existence of separate nesting pairs in the Lower Tunguska River Basin: on the Ko-

chuchuma River (Andreev 1974), in the upper reaches of the Nepa River (Tarasov 1965), and near villages Zdanowa and Erema where they occurred more frequently than common cranes (Sushkin 1938).

Lower Amur Basin

Within the limits of this area nesting of the hooded crane has only been proven by the presence of several nests and broods with downy chicks in the middle reach of Bikin River (Fig. 3) from the Nizhni Pereval to the Ulunga (Pukinsky and Ilyinsky 1977). In this area of 6,000 km², of which no more than 7-12% is occupied by *G. monacha* nesting habitat, 14-16 nesting pairs were recorded.

There is evidence, however, which suggests that this crane inhabits (although in lower population den-



Fig. 1. Hooded cranes at their nest in Ussuriland, USSR (photo by Yuri Pukinski).

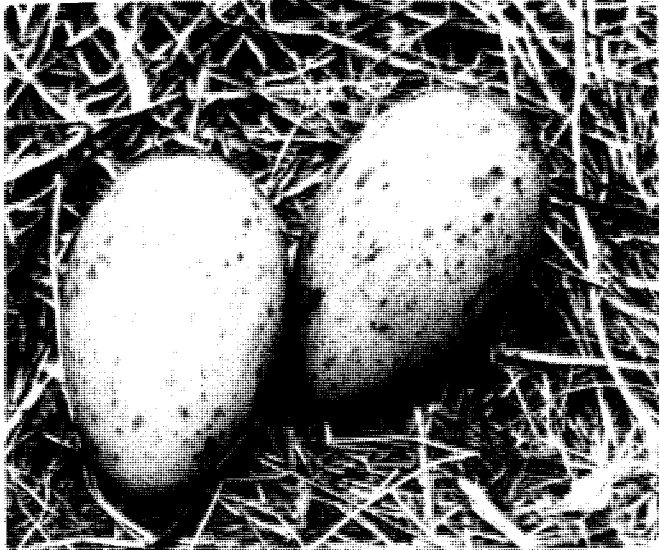


Fig. 2. Eggs of hooded crane (photo by Yuri Pukinski).

sities) the middle reach of the Khor Ri River (another tributary of the Ussuri River) near its confluence with the Anuchinka River (Shibaev, pers. comm.) and lower near Sukpai village (Nazarenko, pers. comm.). It also inhabits Priamurye northeast of Birobidzhan city, the mouth of the Simmi River, close to Evoron Lake and the Evur River Basin (Roslyakov, pers. comm.), the In River Basin and the middle reach of the Mukhen River (Yakhontov 1975), and the upper Gorin River (Vorobiev 1963). The total number of nesting pairs in Lower Priamurye is 35-40 (Roslyakov 1977).

The status of the hooded crane on Sakhalin Island remains obscure. In June 1931 a young crane (unknown age) was obtained in the region of Naira = Gastello (Taka-Tsukasa 1967). On 16 July 1975 L. M. Benkowsky (pers. comm.) observed 1 bird of a pair supposedly living on the Langeri River near Pogranichnoe village.

Other nesting localities of the hooded crane will probably be found in the districts of the Upper Zeya Hollow and Upper Selemdza River, now unexplored by ornithologists, where suitable mossy marshes with thinned shrubs and depressed larches have spread over vast territories (Fig. 4).

DISTRIBUTION OF NONBREEDERS

Like other members of *Grus*, nonbreeders and juvenile hooded cranes wander throughout the summer in nesting regions or on their periphery (Fig. 3), and also far from them in habitats totally different from those mentioned above. In the Soviet Union 2 such important wandering areas are known. Previously they were erroneously thought to be nesting places of *G. monacha*.

The 1st such nonbreeder habitat is in open swampy lowlands in forest-steppes and steppes of southern Middle and Western Siberia westward to Barabinsk Steppe (Zalessky 1921, Ruzsky 1940) where a great number of waterfowl rest, feed, and molt on the vast marshlands and countless lakes. Occupying the upper Ob Basin the region stretches along it from Verkhny Uimon village on the Altai (Grekhova, pers. comm.) northward up to the Ket River (Johansen 1930) and from Bateni village along the Yenisei River (Zalessky 1921) in Tuva to the edges of steppe marshes in the basin of

Tes-Khen River and Tere-Khol Lake (Yanushevich 1952, Golovushkin pers. comm.).

The absence of sightings of immature birds allows me to assume that *G. monacha* does not pass over the above region during the fall migration from nesting areas in the Middle Siberian Plateau. Hooded cranes have been observed there mainly in May-July, but sometimes in August, September, and October as singles, pairs, or in groups of 3-4 individuals. Some of these cranes and *G. grus* molt in almost inaccessible marshy districts and reeds on the shores of lakes. Their secretive molting behavior apparently accounts for the low number of sightings in summer.

Hooded cranes often occur together with the nomadic common cranes: on 2 May 1920 near Tomsk, 3 *G. monacha* with 7 *G. grus*; on 19 June 1920 near Bateni, 1 *G. monacha* in *G. grus* flock; on 20 August 1920 near Urtam village, 3 *G. monacha* in *G. grus* flock (Zalessky 1921); and on 13-14 July near Verkhny Uimon, 3 *G. monacha* with 2 *G. grus* (Grekhova pers. comm.). During migration these 2 species often occur together (Hemmingsen 1951). Possibly common cranes attract nonbreeding hooded cranes that far westward.

The other area of summer wanderings in the USSR is the treeless steppes of Southern Transbaikalia (Dauria) with the Torei Lakes and Borzya Lakes scattered along them. In the past this region must have been 1 of the main concentration sites for nonbreeders. As far back as 1856 Radde (1863) found hooded cranes common on Barun-Torei Lake in the 1st part of June; Stegmann (1928) noted flocks of hundreds (pairs and unmated) on 26-30 June 1925. All the specimens taken by the above authors (Collection of the Zoological Institute Academy of Sciences, USSR) are 1st year birds, and 1 juvenile male was shot on 18 June 1939 on Lake Zun-Aralantuy (Sudilovskaya 1951).

Dolgushin (1941) also thought that *G. monacha* were common on the steppe lakes of Dauria in June-August 1930. Cranes continue to inhabit the area in summer: Leontiev (1976) observed 5 cranes on 15 June 1963, 4 cranes 23 June, and 1 crane in August. Golovushkin (pers. comm.) saw 6 cranes on Lake Zun-Torei on 2 June 1975. However, nonbreeding *monacha* are not as numerous here as they were 50-60 years ago. The main cause of the species' decline is increased disturbance as a result of the increased agricultural activity, sheep and cattle grazing, and uncontrolled hunting on their resting and feeding places. This habitat used by nonbreeders continues into neighboring regions of north-eastern Mongolia and China.

MIGRATION ROUTES

Hooded cranes regularly pass through the entire Transbaikalia (Fig. 3) on the way to their winter quarters and on return to their homeland in the southern Middle Siberian Plateau. Their route and periods of migration can be traced by the following data.

Northern and Northeastern Coasts of Lake Baikal

At Irkana 1 was taken in May 1950 (Gagina 1954); in Tompuda River mouth 1 was observed on 10 April 1958 and flocks of 5-12 individuals were seen flying southward in mid-September (Skryabin and Filonov 1962); and on 18 September 1914 an immature in juvenile plumage was shot near Kudalda (Collection of the Zoological Institute Academy of Sciences, USSR).

Environs of Chita

A small flock was observed on 20 May 1939 in the Shurgaldzhin Basin and 4 birds were observed on 1 May 1953. At the Verchnaya Chita River a flock of 18 cranes was found on 10 September 1926 (Pavlov 1976).

Southern Transbaikalia

A pair was observed in the neighborhood of Aginskoye on 12 May 1963 (Shchokin 1976). On Torei Lakes, Leonteiv (1976) reported spring migration on 28 April 1967 (flock of 8), on 4 May 1967 (10), on 6 May 1965 (5), on 6 May 1967 (2), on 12 May 1967 (3), and on 17 May 1965 (1). On 9 September 1856, Radde (1863) observed there the last *G. monacha* of the season. A small number of nonbreeding hooded cranes remains in summer on this migration pathway north of the most outstanding wandering regions in Dauria. Pavlov (1976) reported a pair in June 1951 in the Orocha River mouth. According to Malyshev (1961) 1 was observed on Chivyrkuisky Bay of Baikal between 21 June and 10 July 1954.

It is quite possible that a small part of the cranes of the Siberian population, and also of cranes from unknown nesting areas north of Amurland, pass (together with few nomadic individuals inhabiting there) over the Zeya Basin and farther southeast

through the vast Middle Amur Plain, where they join migrants from the Lower Amur Basin. Hooded cranes observed on 10 April 1856 on the Amur below the Bureinski Mountains (Radde 1863), in early May in the Lower Bureya River (Pankin and Neufeldt 1976), and on 6 September 1971 on the Zeya near Natalyino (Smirensky and Bohme 1974) may belong to the same category.

The migration through Transbaikalia is very obvious, but at Primorye Territory it is considerably less noticeable. The following data have been reported from there: V. D. Yakhontov (pers. comm.) observed 1 in September 1963 in the middle reach of Bolshaya Ussurka River; on Khanka Lake, in the upper reach of Sungach River in spring 1869, hooded cranes were observed in flight from 23 April until 15 May (Przhevalsky's diary of Ussuriland Expedition); Shibaev (1975) recorded 1 crane on 18 April 1963 and 2 cranes on 19 April 1963; in the Tumannaya River mouth a flock of 7 on 4 April 1965; and on the northern coast of Expedition Bay a migrating flock of 12 was observed on 22 October 1962 (Shibaev 1975).

Apparently *G. monacha* breeding in Bikin-Khor Basin and those inhabiting the area of Priamurye use the same migration route. In spring and fall they pass along the Sungari River of China. In conclusion it should be noted that the present scanty data about the hooded crane suggest that, like the Siberian crane

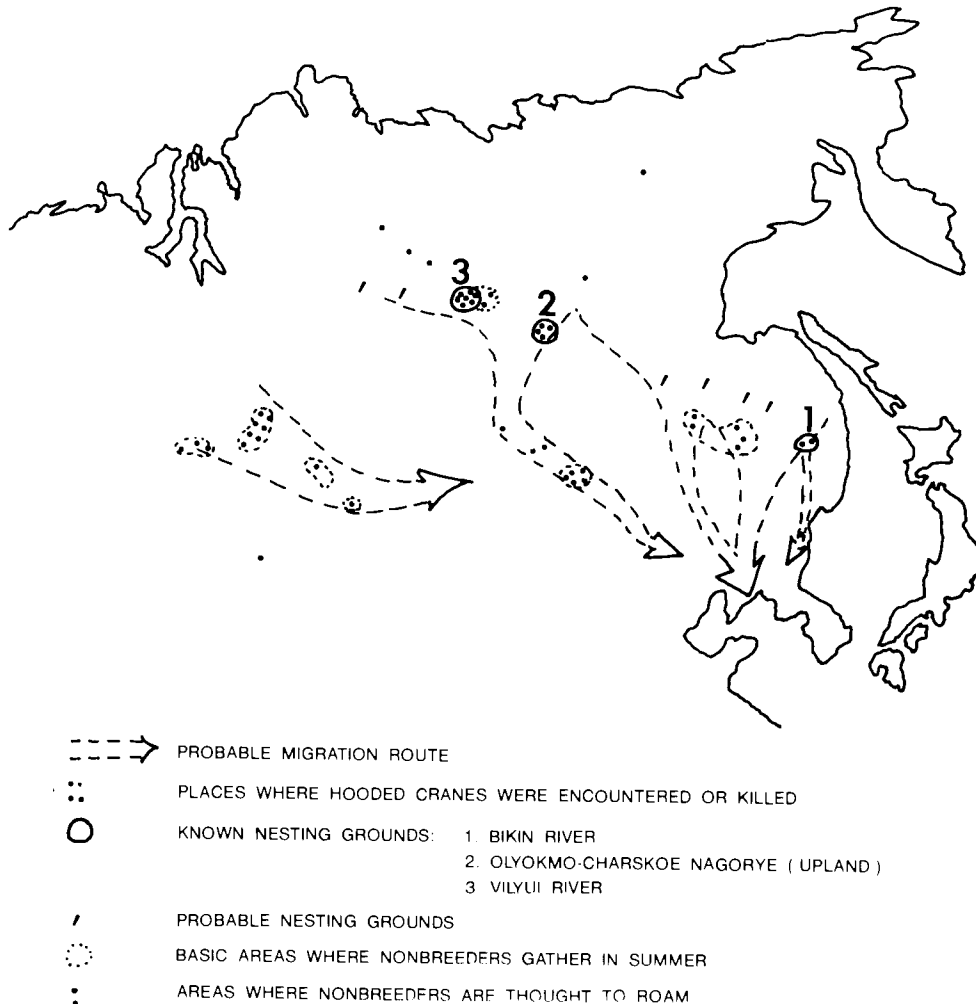


Fig. 3. Distribution of the hooded crane.

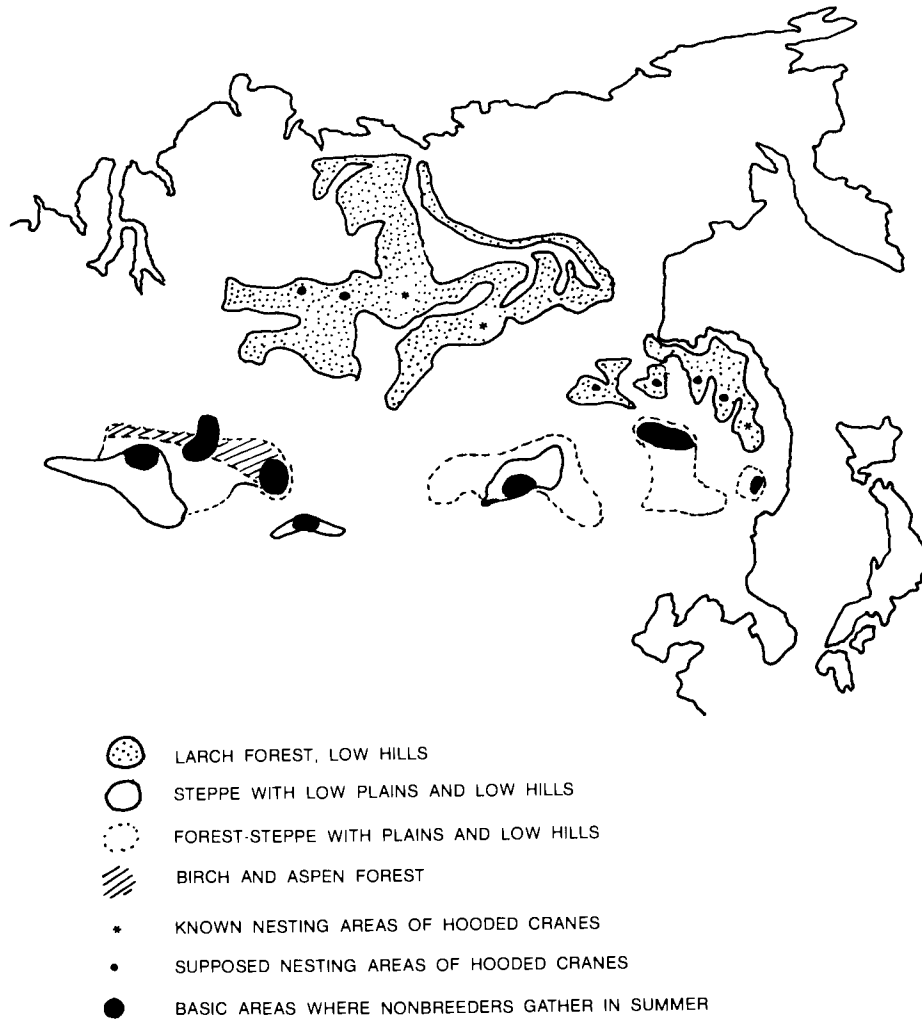


Fig. 4. Geobotanical zones showing probable hooded crane habitat.

(*Grus leucogeranus*), it is endemic to the Soviet Union.

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THE HOODED CRANE AT YASHIRO, YAMAGUCHI PREFECTURE, JAPAN

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Yashiro in Yamaguchi Prefecture is a small basin on a tableland located in western Honshu. About 100 hooded cranes (*Grus monacha*) winter there annually from late October to early March. The author has been studying their status since 1960 and describes their wintering habits, mainly roost habitats and roosting activities, in this paper.

METHODS

The number of cranes was counted daily at Yashiro from the end of October to the beginning of March. The cranes were counted leaving their roosts early in the morning. After their departure, feces and footprints were examined to confirm the exact roost site. Observers were placed at several locations over which cranes were expected to fly and these observers confirmed the flight courses by tracing the cranes' movements from the roost to the feeding area or vice versa. The elevation of the roost and their distance from feeding areas were measured.

A blind was constructed near a roost area and before the cranes arrived at dusk, an observer was in the blind with cameras and binoculars to record their activities. The cranes were counted at each roost at least 6 times during the season. This study has been continued by 1 or more persons since 1960.

Since October 1978 ambient temperature has been recorded with an automatic thermometer set near the feeding area. Climatic records before 1978 were obtained from the weather station in Yamaguchi City.

ARRIVAL, DEPARTURE, AND FLUCTUATION OF POPULATION

Until the 19th century numerous hooded cranes were distributed in many parts of Japan, but they have been hunted since the Meiji revolution and have been protected at Izumi, Kyushu, and Yashiro only since the end of the 19th century. At Yashiro there were 350 cranes in 1940 and the population is now about 100 (Table 1). It is difficult to determine why the population of the cranes has declined because many aspects of cranes' lives are involved. However, the quality of habitats at Yashiro have been declining each year and that may explain the diminishing number of wintering cranes.

The 1st cranes arrive at Yashiro when the minimum daily temperature drops below 3°C, usually late in October or early in November. Thereafter populations increase as the temperature declines and they reach maximum numbers in mid or late November. They begin leaving Yashiro when the maximum daily temperature exceeds 10°C in late February or early March (Table 2).

Table 1. Populations of hooded cranes at Yashiro, Japan, 1869-1979.

Winter ^a	Population	Winter	Population	Winter	Population
1869	10	1952	150	1967	90
1897	33	1953	156	1968	78
1907	55	1954	150	1969	78
1912	65	1955	150	1970	91
1919	85	1956	145	1971	108
1921	100	1957	130	1972	104
1926	140	1958	120	1973	134
1933	140	1959	115	1974	90
1940	355	1960	132	1975	108
1945	250	1961	108	1976	110
1947	200	1962	111	1977	105
1948	155	1963	110	1978	87
1949	120	1964	109	1979	73
1950	160	1965	101		
1951	165	1966	125		

^aExample: 1869 = October 1869 to March 1870. Population numbers before 1948 are approximate.

Table 2. Ambient temperature and number of cranes at Yashiro, 1 February to 9 March 1980 (based on data of K. Hironaka).

Date	Temperature (°C)		Cranes	Date	Temperature (°C)		Cranes
	Minimum	Maximum			Minimum	Maximum	
21 Feb	-3	6.5	73	1 Mar	8	10	73
22	-3.5	6.0	73	2	-2.5	10	73
23	-3	9.5	73	3	-0.3	7	73
24	-2	10.5	73	4	0	8	73
25	-2	11.0	73	5	2	8.5	73
26	2.5	6.5	73	6	-2	12.5	4
27	1	10.5	73	7	4.3	9.5	4
28	1	7.5	73	8	0	11.2	4
29	-3	10.5	73	9	5.5	9	0

Table 3. Ambient temperature and number of cranes at Yashiro, 3 November 1979 to 4 January 1980 (based on data of K. Hironaka).

Date	Minimum (°C)	Cranes	Date	Minimum (°C)	Cranes	Date	Minimum (°C)	Cranes
3 Nov	9.3	0	24 Nov	-2.0	10	15 Dec	0.6	36
4	14.3	0	25	2.0	10	16	-2.9	36
5	14.2	0	26	1.2	10	17	-3.0	36
6	5.3	0	27	0.0	14	18	-2.3	36
7	3.0	7	28	8.2	14	19	1.2	36
8	4.2	7	29	5.0	14	20	8.1	36
9	8.5	7	30	-3.0	22	21	2.5	36
10	14.5	7	1 Dec	-1.0	22	22	8.5	36
11	13.2	7	2	-0.2	22	23	4.0	36
12	8.0	7	3	-1.8	22	24	1.4	36
13	4.0	7	4	9.5	22	25	-4.0	36
14	0.7	7	5	11.7	22	26	-0.2	44
15	-2.0	7	6	6.7	22	27	-4.0	44
16	1.0	7	7	-0.3	22	28	-1.0	44
17	7.0	7	8	0.0	22	29	3.5	44
18	9.0	7	9	-0.2	22	30	-1.0	71
19	0.0	7	10	-0.3	22	31	-1.0	71
20	-2.1	7	11	2.0	22	1 Jan	3.7	71
21	-0.2	7	12	-1.2	36	2	3.0	73
22	3.7	7	13	10.0	36	3	6.0	73
23	5.0	7	14	-1.2	36	4	5.0	73

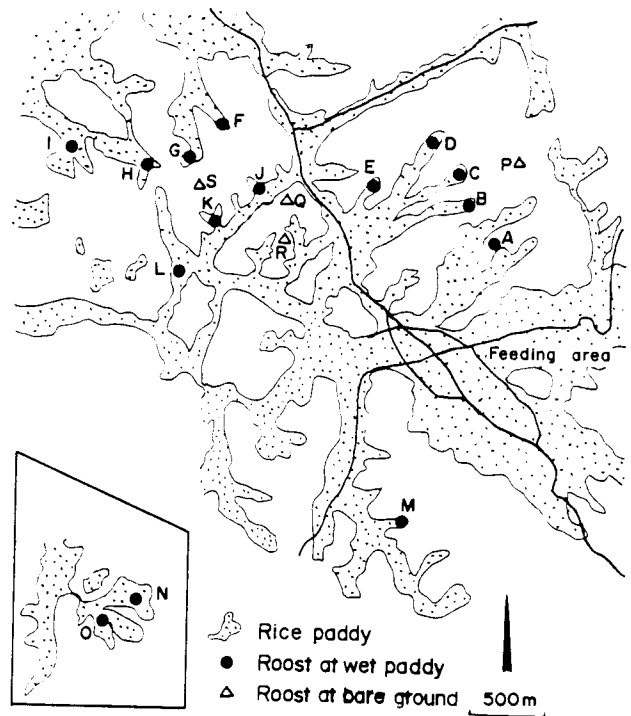
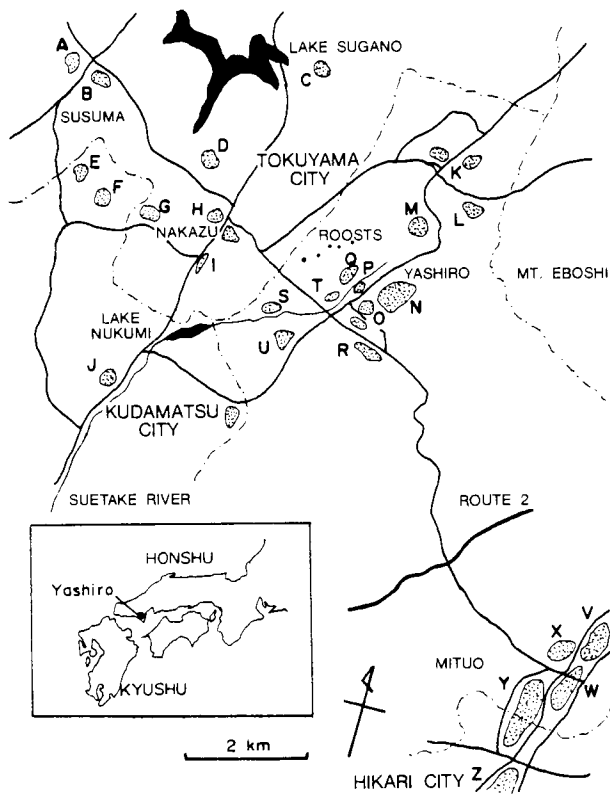


Fig. 2. Distribution of roosts at Yashiro (Table 4). Roosts N and O (in small insert) are located about 15 km southeast of Yashiro.

Fig. 1. Distribution of hooded crane feeding areas at Yashiro, Japan, 1962-1964.

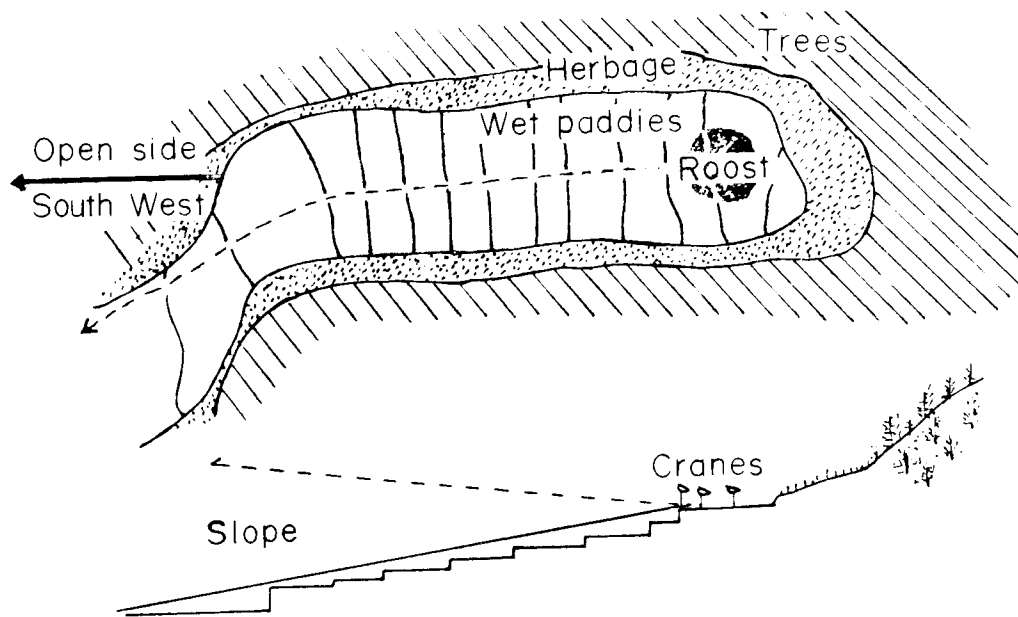


Fig. 3. Above: aerial view of roost E. Below: longitudinal view. Dotted lines indicate flight pattern from roost.

The cranes initiate spring migration during the morning of a nice day when atmospheric pressure is high in Japan. In some situations they all depart in 1 day; in others, departure of the entire population requires several days. In the mild weather in winter 1979-1980 the cranes arrived later than usual (Table 3).

DISTRIBUTION OF FEEDING AREAS

The locations of feeding areas commonly used by some flocks or families are shown in Fig. 1. Thirty-eight feeding sites observed from October 1962 to March 1964 contained 2 to 26 ha. The cranes visit small and large feeding areas near their roosts but visit only large areas located far from their roosts. Most of the feeding areas are harvested rice paddies where they eat waste rice. The geographic center of these feeding areas is Point N in Fig. 1 and most cranes stay there in separate flocks or families.

The cranes assemble at Point N before flying to the roost each evening and before departing on spring migration¹. The cranes are fed there and people are prohibited from approaching the area. Points Q, Y, and W are also used by flocks; the other sites are used only by families. In the winter of 1979 Points N and O were frequently used, while Points Y, R, O, P, Q, and E were used only briefly. This difference in frequency of use is probably because Point N had an abundance of food.

DISTRIBUTION OF ROOSTS AND THEIR ENVIRONMENT

From 1960 to 1975 cranes spent the night at 15 roosts (A-O) which were wet paddies (fields covered with shallow water) and occasionally at 4 roosts (P-S) which were bare hilltops, the shore of a pond, or a hillside covered with small trees. Roosts A-E, M, P, Q, and R are distributed at Yashiro, Kumage Town, and included in a wildlife protection area. Roosts F-L are distributed at Nakasu, Tokuyama City, and roosts N and O are at Nakayama, Shuto Town (Fig. 2).

Typical circumstances of a roosting place are shown in Fig. 3. The altitude of roosts at Yashiro are 329-390 m above sea level and 0-70 m above feeding areas. The main roosts are 40-70 m above the feeding areas. It is 0.7 to 3 km between feeding areas and roosts at Yashiro and 7 to 10 km at Mitsuo. Roosts are often surrounded by mountains on 3 sides, with 1 open side regarded as an entrance (Fig. 3). The entrances face many directions, but southwest seems preferred. The steeper the mountain slope approaching the entrance, the more convenient it is for cranes to fly up it.

A large area including many sections of wet paddies is preferable and the roost should be at least 10 m wide. Water depth in the paddies is 1 to 7.5 cm and the depth of mud beneath the water is 4 to 11 cm. Cranes also prefer flowing shallow water, about 15 cm deep. The roosts contain shallow water because they are underlain by granite (Kamamura 1975).

ACTIVITIES AT THE ROOST

Two types of roosting behavior are evident. In the 1st type cranes leave the feeding area before dark,

¹(Editors' note) Similar behavior has been noted by Khacher (this Proceedings) and by Wheeler and Lewis (1972). Trapping techniques for sandhill crane studies in the Platte River Valley. U.S. Fish and Wildlife Service, Resource Publ. 107. 19 pp.) in black-necked and sandhill cranes, respectively.



Fig. 4. Hooded cranes sleeping at roost C at 2300 hours, Yashiro, Japan.

land at places such as Point P (Fig. 2) until almost dark, and then fly to the roost. In the second type they stay at the feeding area until dark and then fly directly to the roost. In both instances it is as dark as 0-50 luxes when they fly to the roost. After landing they drink water, make the "unison call," or walk about for awhile. Later they quiet down and only occasional low vocalizations are heard.

Photographs taken every 30 minutes show that the cranes move closer together as time passes, but never closer than 40-50 cm apart (Fig. 4). We imagined that the cranes would rest facing the roost entrance, prepared for immediate flight in an emergency. But they do not always face the entrance (Fig. 5). An observation of cranes attacked by a predator indicated that the individuals on the roost periphery took flight 1st, moving in all compass directions, and then the cranes in the center of the roost took flight, avoiding collision with other cranes.

NUMBER OF CRANES AT ROOSTS

The average number of cranes counted at each roost (Dec.-Feb.) is shown in Table 4. Roosts F, J, L, N, and O were each occupied by a family group. The family roosted at N never associated with other groups or flocks. Roosts used frequently are E, K, and M, and these have been used annually since 1960.

Factors influencing the loss of roosts have been as follows: Trees being planted or growing up (roosts C, R, S, and parts of E and K), construction of a golf course (F, G, I, L, and M), construction of an oxen-

shed (D), becoming dry land (J, N, and O), becoming dry paddies (A, L, and part of D), and a reduction in area of mudflats (B and C). Roost D was not used this past winter (1979-80) because it was not wet enough and an oxshed was built nearby. Roosts C and E were not muddy enough then and nearby trees grew too tall. Consequently cranes had to use dry rice paddies as roosts, which was very dangerous for them.

The numbers of the cranes seen at several roosts during October 1979-March 1980 were as follows: Roost M--33, 37, 69, and 32 (not used at the end of January because of freezing); Roost E--6, 10, 2, 18, and 9 (roost seemed in good condition but was used only by a small group). Roost K--5 (used only in November and December); Roost P--6 and 30 (used occasionally); and Roost B--7 (believed to have been used 2 or 3 times). A dry rice paddy near the roosting area, which contained 18 and 29 cranes respectively on 2 occasions, was believed to have been used 5 or 6 times.

CONSERVATION

Cranes are marsh inhabitants. Yashiro, although it lacks marsh, has a substitute, i.e., wet paddies in long narrow valleys far from human habitation. Agricultural practices have preserved this environment. Now however, farmers operate modern machines and paddies are well drained. Because of recent agricultural practices, paddies are now being turned into forests

or deserts. The habitats available to cranes are diminishing each year.

Kumage Town, which is responsible for the cranes, has purchased 54,166 m² of fields as feeding or roosting areas. But cranes are very wary and need a large home range. They do not use a small feeding area even if the area is safe; thus, a large area must be closed to trespass by people. There are many other problems, e.g., Point N is too crowded for available food (Fig. 1) and only 5 roosting areas are now used, though the cranes formerly roosted at 21 sites. At the minimum, roosts at B, C, D, E, K, and M must be preserved.

DISCUSSION

The roosts used by cranes have some characteristics that contribute to their safety. They are remote from human habitation. They are surrounded by mountains except on 1 side, which helps cranes to observe predators (e.g., fox) approaching them. Terrain surrounded by mountains helps prevent sudden drops in air temperature. One open side makes the wind blow upward. When the roost entrance faces southwest, the terrain protects cranes from cold northwest winds. The southwest exposure means longer duration of sunshine which helps keep the water from freezing. Considerable slope helps their immediate takeoff. Shallow water makes it difficult for predators to approach and cranes can drink the water.

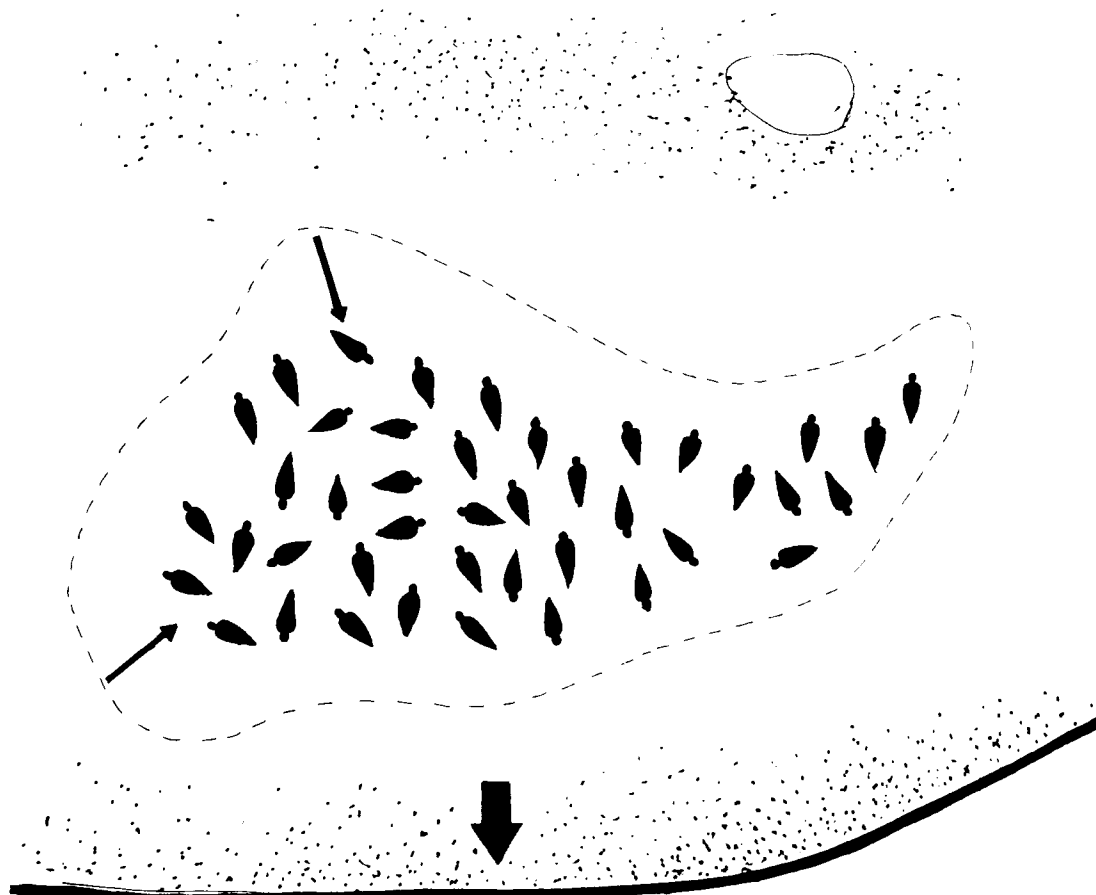


Fig. 5. The positions and directions that cranes faced in a roosting flock. The broad arrow indicates the entrance to the roost. The narrow arrows show that cranes tended to face the center of the roost.

Table 4. Average numbers of hooded cranes at roosts shown in Fig. 2.

Roost	1961 ^a	1962	1963	1966	1971	1973	1974	1976	1977	1978	1979
Wet paddies											
A	0	7	8	0	?	3	7	0	X	X	X
B	5	7	6	?	10	17	7	3	3	0	5
C	0	0	?	?	?	38	35	0	13	0	0
D	26	28	24	37	18	18	10	49	29	48	0
E	13	8	14	16	12	7	3	9	11	16	7
F ^b	3	3	3	2	2	2	X	X	X	X	X
G	3	8	9	7	11	0	X	X	X	X	X
H	4	8	3	7	12	5	X	X	X	X	X
I	16	9	13	19	6	6	X	X	X	X	X
J ^b	4	4	2	0	0	0	X	X	X	X	X
K	32	29	18	22	25	19	5	11	8	8	6
L ^b	4	4	2	0	0	0	X	X	X	X	X
M	?	11	9	11	13	19	29	13	43	34	43
N ^b	?	?	?	?	?	?	4	2	2	2	X
O ^b	?	?	?	?	?	?	4	2	2	2	X
Bare ground											
P	2	3	2	4	3	16	2	4	6	4	18
Q	3	3	3	2	3	3	0	3	0	0	0
R	3	3	3	3	0	0	0	X	X	X	X
S	4	4	0	?	0	0	X	X	X	X	X

^aExample: 1961 = Dec. 1961-Feb. 1962. An X indicates that there was no use of the roost that year. A ? indicates that the roost was not censused. A zero indicates the roost may have been used but cranes were not seen on the survey dates.

^bFamily group only.

Cranes land at their roosting area just before dark and concentrate at the middle of a muddy rice paddy. These characteristics help protect them from enemies. At a roost, they keep a moderate distance between each other, and this distance may help them avoid wing contact in case they must take flight quickly. Cranes rest on 1 leg but they move occasionally to keep their

legs from being frozen.

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Crowned Cranes



West African crowned crane (photo by L. Walkinshaw).

WEST AFRICAN CROWNED CRANE STATUS

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Abstract: This report concerns the 1974 status and some other aspects of the West African crowned crane (*Balearica pavonina pavonina*). Data have been obtained from correspondents, personal experience, and the literature but coverage of the French literature has been less extensive than review of English literature. The breeding and general biology of this subspecies does not differ materially from the Sudan crowned crane (*B. p. ceciliae*) to the east nor from the closely allied South African crowned crane (*B. regulorum*) of eastern and southern Africa. The subspecies is widespread in seasonally moist grassland near river systems from between 10° and 15° N latitude eastward to the eastern edge of the Chad Basin. There is a little human hunting pressure but numbers do not appear to have diminished. Although the modification of wetlands is likely to impose a greater threat than is hunting, the crane is not presently endangered.

Accounts of the habitat, food, behavior, and nesting of *Balearica* cranes are found in standard regional texts. The only recent studies are those of Walkinshaw (1964, 1965, 1966) mainly on *B. regulorum* but also on *B. p. pavonina*. It is probably correct to say that studies have not yet been sufficiently detailed for any biological differences between the 4 populations of the 2 species to have emerged, and accounts do not differ in detail.

FOOD

A major part of the diet of *B. p. pavonina* is obtained from cereal crops such as millet, guinea-corn, and rice (Bates 1934). Wild rice (*Oryza sativa*) is taken in Cameroun (D. A. Holmes, pers. comm.) and nearly all of the few northern Ghanaian records refer to birds on cultivated rice fields (F. Walsh, pers. comm.). Flocks on the South Chad Irrigation Scheme at Gambaru were eating "...what appeared to be grass roots" (P. Hall, pers. comm.). With the gradual spread in West Africa of rice culture and of such irrigated cereals as wheat (e.g., in northeast Nigeria) it seems likely that the cranes may become pests. Grasshoppers sometimes predominate in the diet, as in Chad (Salvan 1967).

BREEDING

Walkinshaw (1966) made detailed observations in central Nigeria. Throughout the range the breeding season corresponds with the late rainy season, i.e., young occur in December or even later, well into the dry season. Some locality dates: breeds in September and October (Cawkell and Moreau 1963) in Gambia; in Senegal nests in September and October, clutch of 3 on 10 October; in Chad fledging 16 October at Matadjene, the most easterly breeding record of the subspecies (Salvan 1967); in Nigeria on the Jos Plateau the species nests from July through September (clutch of 2 eggs on 31 July, 4 clutches of 3 hatched 1 August, 3 August, 2 August, and 18 August, respectively [Smith 1962, 1964], eggs laid 30 July, 2, and 4 August; eggs laid 6, 8, and 10 August hatched 6-7 September; eggs laid 13, 14, and 16 August, a clutch of 3 found on 16 August, clutches of 2 and 3 on 17 August [Walkinshaw 1966]; clutches found on 30 July and 22 September [Serle 1939]).

SEASONAL MOVEMENTS

Observers have not reported that the West African crowned crane is a regular migrant, but daily roosting-foraging movements apparently may be quite distant, some 10's of kilometers, because they sometimes occur far from the nearest water, e.g., a record at

Taberreshat in Mali (Bates 1934). There is a marked seasonal change in habitat, from inundated or moist ground or farmland in the breeding season to arid Sahel sand plains with scattered palms in the dry season (Golding 1934). To the southwest of Lake Chad, P. Hall (pers. comm.) believes that there is a seasonal movement between clay plains near Baga and breeding grounds at Waza.

DISTRIBUTION

The absence of long-distance migratory movements facilitates mapping of the range. Figure 1 includes all records culled from the Nigerian Field (1935-1973), the Bulletin of the Nigerian Ornithologists' Society (1964-1973), correspondents P. Hall, D. A. Holmes, F. Walsh, J. P. Vande Weghe, and J. B. Wood (to whom grateful acknowledgment is made) and about 60 papers on bird distribution in western Africa. Some key references in the French literature have not been consulted, e.g., Bouet (1952-1961), Duhart and Des-camps (1963), and Malzy (1962).

The crowned crane is common on the middle Gambia and the lower Senegal Rivers and is widespread in these territories; it is not very common in the Inundation Zone of the Niger River, nor on that river in Niger Republic (although apparent abundance doubtless fluctuates with the heights of water and exposure of sandbanks). These cranes were listed as common at Sokoto in Nigeria by Dobbs (1959) but may have declined in this area because subsequent observers have not reported it nearby (e.g., Mundy and Cook 1971). It is widespread in permanent wetland areas of northern Nigeria (Fig. 1): (1) on the lower Kaduna and adjacent parts of the Niger Rivers; (2) on the Jos Plateau, particularly around Vom; (3) on the Benue River and adjacent marshes east of about 8° E, with large flocks about 12°-13°E; (4) along seasonally inundated areas of the Komadugu Gana River from Hadejia east to its outfall into Lake Chad; and (5) in marshes around Lake Chad (not north of 14°N) and especially in the area between Marte (Nigeria) and Waza (Cameroun), where the species reaches its greatest concentration (Fig. 2). Farther east in the Chad Basin the population is more sparse, but flocks up to 500 occur on the Batha watercourse (Salvan 1967). Total populations in these 5 Nigerian areas are probably in the (1) low hundreds, (2) high hundreds, (3) and (4) low thousands, and (5) low 10 thousands.

On the plains south of Lake Chad, P. Hall has records of flocks of over 80 birds near Baga in March and 10 or less in July-September, 3 at Marte in May, and 200 at Gambaru in February. Holmes (1972) never saw them west of the Yedseram channel; pairs were common

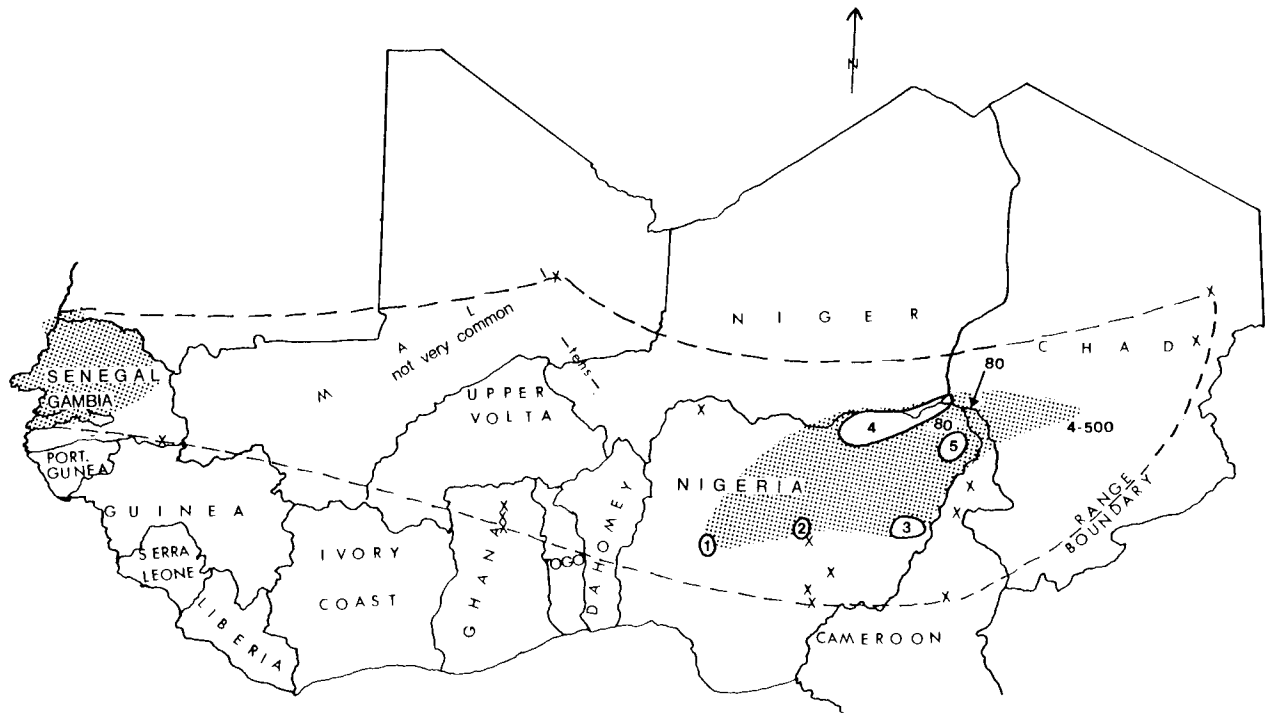


Fig. 1. Distribution of the West African crowned crane. Dotted lines are regions of high concentrations. X's indicate locations where sighted. Encircled numbers correspond to the 5 areas described in the text. Other numbers indicate known population size. Flocks up to 300 are seen in Senegal.

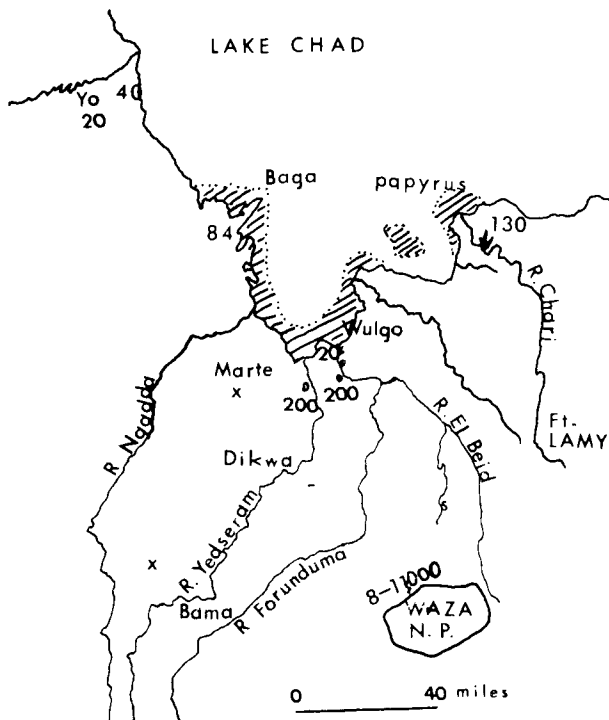


Fig. 2. Detailed population distribution area around encircled area 5 of Fig. 1.

in the Ngala clay plains in October and November, and in January they became concentrated in the swamps south of Logomani (about 200 birds). In February only a few occur at the Gambaru Irrigation Scheme. Holmes (1972) estimated that in February between 8,000 and 11,000 crowned cranes congregated on the wild rice marsh at the west edge of the Waza National Park (pers. comm.). This marsh probably exceeds 10,000 ha and consists mainly of wild rice with a peripheral zone of the shrub *Sesbania*, and *Balanites aegyptiaca* on better drained soil. The marsh borders the Park but lies outside it. Holmes (pers. comm.) says that "The 1971 monsoon reputedly brought below average rainfall, so the clay plains south of Lake Chad dried out earlier than usual. Probably the cranes become concentrated around the remaining pools as the dry season advances; thus there were some 300 in the small swampy area south of the Ngala-Logomani road on 16 January (some of these were exhibiting courtship activity). There is a larger swampy area a few miles farther south which (with the few remnant swamps such as the one at Waza in drier years) probably assume much greater importance."

HUNTING

The species appears to be regarded with toleration, even affection, by the endemic peoples and is frequently kept in captivity. It is not hunted for food or sport by native or expatriate people. However, P. Hall says (pers. comm.) that on the Yo irrigated wheat scheme his game scout caught a hunter in October 1972 in illegal possession of 22 crowned cranes. In Nigeria they are listed as a 2nd-schedule species and afforded special protection. But the schedule enables the hunter to catch 4 a year in areas outside game reserves and in other areas endorsed on his license; 1 such area is the lakeshore between Baga and Gambaru

and another is adjacent to Waza National Park. In December 1972, Hall caught a hunter at Nguru in illegal possession of 33 crowned cranes and 32 European white storks (*Ciconia ciconia*) which the hunter intended to export to Europe via Kano. The cranes had probably been captured between Nguru and Geidam.

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THE SUDAN CROWNED CRANE

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The Sudan crowned crane (*Balearica pavonina ceciliae*) occurs in Sudan, Ethiopia, northern Kenya, and northern Uganda. Within this area its limits are in the north 13°10'N, 32°40'E (Kosti, Sudan), in the west 12°54'N, 23°29'E (Zalingei, Sudan), in the south 03°40'N, 32°10'E (Nimule, Uganda), and in the east 08°53'N, 39°53'E (Lake Basaaka, Ethiopia). In Sudan it is found along the White Nile and its tributaries in Darfaw, Khartoum, Bahr el Ghazel, and Equatoria Provinces; in 1900 it occurred as far north as Khartoum 15°36'N, 32°31'E (Walkinshaw 1964, 1973; see both publications for known localities of the crane in Sudan).

In Ethiopia this crowned crane is found in marshes and along lake shores and rivers of the western highlands (Eritrea, Tigre, Begemder, Gojjam, Shoa, and Kafa Provinces), Rift Valley lakes region (Shoa Province), and western lowlands (Illubabor and Gemu Gofa Provinces) (Urban and Walkinshaw 1967, Urban and Brown 1971; see former for known localities of the crane in Ethiopia). Since 1967 it has also been observed in northwestern highlands in the Asmara and Axum-Adua areas (Ash, unpubl.).

In Kenya it is found at the north end of Lake Rudolf (Owre 1966), an occurrence continuous with the species' presence in the lower Omo River Valley and delta in Ethiopia. In Uganda, 2 individuals were once seen close to the Sudan border at Dafile near Nimule (Jackson and Sclater 1938). This crane has not been recorded elsewhere in Uganda.

MIGRATION

Although the crane is known to flock in the non-breeding season, often in large numbers, the exact movements and numbers have not been recorded. In Sudan's White Nile valley flocking of crowned cranes begins in November after the breeding season and peaks in late February and March; in Malakal in late February the cranes numbered several thousand (Walkinshaw 1964). Undoubtedly these large flocks have been witnessed by many observers; however, the exact details have not been published. In Ethiopia the birds are known to flock at least in the west in Illubabor Province: in March 1967, 250 individuals were seen in a restricted marshy area along the Baro River at Gambela 08°15'N, 34°35'E (Urban, unpubl.).

In the marshes along the east side of Lake Tana (Begemder Province) the crane is numerous and mainly in pairs in August and September when it nests (Urban and Walkinshaw 1967) but absent in February after nesting is completed (Urban, unpubl.). Ash (pers. commun.), mapping the distributions of birds of Ethiopia, has not recorded crowned cranes from May to August (1969-1973). Therefore, it is reasonable to assume that crowned cranes in Ethiopia, like those in Sudan, undergo extensive movements. The details of these movements remain to be determined.

HABITATS

Details on the preferred habitats of the Sudan crowned crane have not been recorded. Based on the vegetation and general ecology of the localities where

crowned cranes have been seen, especially in Ethiopia, the birds prefer, 1st, freshwater marshes; 2nd, open dampish fields; and 3rd, partly submerged vegetation and open areas along shorelines of freshwater lakes and rivers. Rarely are they associated with alkaline lakes. The cranes also nest in the preferred freshwater marshes. Urban and Walkinshaw (1967) provide a brief description of the nest and vegetation of the nesting area in Ethiopia.

POPULATION MAGNITUDE

The total population of the Sudan crowned crane is unknown. This crane, however, is in no danger of extinction¹. Rather it is holding its own and may be increasing. For example, they are abundant in parts of Sudan according to Walkinshaw's (1964) reports of "several thousand" at Malakal and "tremendous flocks" near the White Nile. In Ethiopia it is common to abundant at least in the western lowlands (see above 250 birds at Gamela and in the marshy areas east of Lake Tana during the breeding season; see Urban and Walkinshaw 1967 for detailed counts, e.g., 26 August 1965, 57 individuals seen during a drive of 20 km). Elsewhere in Ethiopia the crowned crane is frequently seen singly, in pairs, or in groups of 5-10.

CONSERVATION

No extensive study on the biology of the Sudan crowned crane has been published, consequently possible survival problems facing it are unknown. In Ethiopia the species nests in areas close to human habitation and seems comparatively undisturbed by man. There the crane's habitats include a wide diversity of vegetation and land uses that are in no immediate danger of alteration. Based on the large numbers of the Sudan crowned crane in western Ethiopia and Sudan, this species is 1 of the most successful cranes of the world.

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¹Editor's note: This report was completed in 1974 and since then wars, drought, civil unrest, and famine among the human populace have struck most of the birds' range. The consequence to the cranes is unknown but probably has been detrimental.

WEST AFRICAN CROWNED CRANE OBSERVATIONS

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Abstract. During July and August 1965, I studied the West African crowned crane (*Balearica pavonina pavonina*) in Plateau Province, northern Nigeria. At least 72 birds were observed; 3 had been captive-reared but were free-living. Eight nests were found between 30 July and 17 August; 6 were in agricultural lands flooded a few inches by heavy summer rains. The other 2 nests were in natural wetlands, 1 where the water was 61 cm deep. At least 15 nesting pairs were among the 72 birds (41.7%). Nests were constructed of the nearest plants, placed in haphazard piles, slightly concave in the center. Measurements of 8 nests averaged 88.2 (68.6-109.2) by 105.9 (71.1-139.7) cm. One of the largest was the deepwater nest, 94 by 121.9 cm across. Eggs found in 7 nests were light bluish. Two clutches, which may have belonged to the same pair, contained 1 and 2 eggs, respectively. Both had been deserted because of human disturbance. Five nests contained 4 clutches of 3 eggs and 1 of 2 eggs. The mean measurements and weights of 16 eggs were 80.9 (SD \pm 3.0) by 57.7 (SD \pm 1.8) mm and 143.0 (SD \pm 13.4) g. At 1 nest, eggs hatched 28 days after the last egg was laid. Seventy-two birds were found in an area of 755 square miles, but a much denser population was found northwest of Vom where 7 pairs and 34 nonbreeders were in 21 square miles, and 4 of these pairs nested within 2 miles of 1 another.

The following observations (Fig. 1) were made in July and August 1965 when I was studying the West African crowned crane (Fig. 2) in northern Nigeria.

- | | | | |
|--------|--|--|--|
| | 3 Aug | Rain showers in morning, 4 hours in field, 4 miles walked, Vom to near Kafo on foot, 2 cranes observed and a nest found with 1 egg (nest No. 2). | |
| 23 Jul | Lagos to Jos (by air) to Vom (with Dr. and Mrs. Victor W. Smith). No cranes observed. | 4 Aug | Overcast, rain in afternoon, 8 hours in field, 5 miles walked, 5 miles on foot, 12 miles by car. Vom to Sacred Grove to Kafo; 6 pairs of cranes and 2 singles observed. |
| 24 Jul | 7.25 hours Vom to Kafo, 4.5 miles on foot, 6 cranes feeding on plains in 1 flock in the afternoon. | 5 Aug | Overcast, cool (rain during night), 9 hours in field, 5 miles walked, 12 miles by car. Two groups of cranes observed near Kafo. Vom to Sabon Gida Lake in afternoon. |
| 25 Jul | 8 hours, 35 miles by car, 3 miles walked, Vom to Jos to Sabon Gida, no cranes observed until we came back to Vom, where 2 were observed flying. | 6 Aug | Overcast, some rain, 5 hours in field, 1.5 miles on foot, 8 miles by car. Vom to Sacred Grove where 2 cranes were observed. |
| 26 Jul | 7 hours, 22 miles driven, 4 miles walked, Vom to Kafo. At Vom (Water-tower Hill) 2 cranes observed flying; near Kafo groups of 7, 2, and 2 (the 2 groups of 2 were definitely breeding pairs). | 7 Aug | Overcast to clear to rain. Nine hours in field, 5 miles walked, and 64 miles driven. With the Victor Smiths drove to Kwi. Two cranes observed feeding on fields near hills. |
| 27 Jul | 9 hours, 12 miles driven, 9 miles walked, Vom to beyond Kafo. A flock of 12 flying, then 6 and 2. Went to Kuru in afternoon. | 8 Aug | Overcast to some rain in afternoon, 8 hours in field, 1.5 miles walked and 65 miles driven. Vom to Sacred Grove, then to Hoss Station in afternoon. Two pairs at Sacred Grove, then groups of 2, 1, and 3 at Hoss Station. |
| 28 Jul | 3 hours, 6 miles driven, 1 mile walked. No cranes observed, heavy rain. | 9 Aug | Some rain, early and late, 10 hours in field, 4 miles walked. Later went with Hillary Fry by Land Rover 68 miles. Cranes observed (nest No. 3 found): 2 cranes at Sacred Grove, their nest, and 2 eggs; 2 more cranes beyond there; 1 at Kafo in rice field; 4 in a group and 1 flying at Kurru Falls; and 1 at Barikin Ladi, north of Ropp. |
| 29 Jul | 10 hours, 65 miles by lorry (with driver Garba Sole), Vom to Tenti, Bokkos, and Mbar. One pair of cranes observed at Mbar; another pair at Kuba. Many reports that cranes had been eliminated from the area by shooting. | 10 Aug | Overcast, some rain, 3 hours in field, 2 miles walked, 12 miles by car. Vom to Sacred Grove, 2 groups of 2 cranes observed. |
| 30 Jul | 8 hours, 12 miles driven, and 4 miles walked, Vom (sugar cane patch) to Kafo. Nest found with 1 egg and pair observed in sugar cane patch; 28 feeding on plains beyond Kafo on south side of road and 6 on north side. | 11 Aug | Cloudy to steady drizzle, 10.5 hours in field, 9 miles walked, 2 miles by car. Went to Sacred Grove (this nest had 3 eggs) then went to Kafo; 5 pairs of cranes observed. |
| 31 Jul | 4 miles walked, 10 miles by car. Walked from Vom to sugar cane patch, to Sacred Grove to Kafo and beyond. One crane observed going to nest at sugar cane patch. Two others observed at Sacred Grove. | 12 Aug | Clear to heavy thundershowers. Watched the pair of cranes all day at nest 3 in the Sacred Grove area. Dayling, 0600 until 1845 hours. Male incubated 0729-0803, 1014-1127, and 1412-1645 hours. Female incubated all night until |
| 1 Aug | Some rain, 8 hours in field, 2 miles on foot, 65 miles by car. Two cranes observed. | | |
| 2 Aug | Semi-clear, 11 hours in field, walked 11 miles, 5 miles by car, Vom to beyond Kafo. Observed groups of 2, 9, 2, 2, and 1 cranes. | | |

0729, 0925-1014, 1127-1157, 1300-1412, and 1715 through the night (dark at 1845 hours). No birds on eggs 0803-0925, 1157-1300, and 1645-1715 hours. Two other cranes seen also.

13 Aug Clear to heavy rain. Watched the pair of cranes at nest 3, Sacred Grove again all day, 0630-1845 hours. Female incubated all night until 0630, 0731-0915, 1057-1158, 1217-1402, 1445-1536, and from 1820 through the remainder of the night. The male incubated 0630-0731, 0915-1030, 1158-1217, 1402-1445, and 1536-1820 hours. From 1030-1057 neither bird remained at the nest. At 1830 the male flew 3 miles up onto a rocky hill for the night. He roosted either on rocks or a lone tree there. Five cranes seen during day.

14 Aug Built a blind and moved it to nest 3 at Sacred Grove, overcast. Hillary Fry identified 3 items used by crowned cranes for food: millipede (*Spirostreptus* sp.), a snail (*Archachatina* sp.), and a crab (*Potamon* sp.). Two cranes at nest. At Kafo found nest 4.

15 Aug All day spent in blind at nest 3. There had been rain during night but day was clear. Another pair observed in the vicinity.

16 Aug Victor Smith took me to Barikin Ladi and we found nest 5; 5 hours in field, 2 miles walked, 41 miles driven. Only 1 crane seen at nest.

17 Aug Clear to heavy thunderstorm, 11 hours in field, 7 miles walked, and 7 miles by car. Five pairs of cranes observed and a group of 6; 3 nests found. Vom to Kafo and beyond. Two nests had 3 eggs each; the 8th nest was empty.

Nests of the West African crowned crane found during this period were:

Nest 1 Found 30 July amidst tall grass and weeds on the edge of a sugar cane patch, 1 mile NE of Vom, Plateau Province, Nigeria. A haphazard mass of grass and weeds with some water around but very little. The nest measured 68.6 by 81.3 cm across. It contained 1 light bluish egg, which was gone when Victor Smith and I visited the nest 1 August. It had been taken by some bird, apparently a pied crow (*Corvus albus*), because women workers had kept the cranes away from the nest for several hours the day before.

Nest 2 Found 3 August. A pile of grasses and weeds on dry land between 2 ditches in sugar cane field. It measured 68.6 by 71.1 cm across and was slightly depressed in the center. It contained 1 egg. On 5 August it contained 2 eggs I discovered after a woman and girl came to work in the field only 35 m from the nest. Both birds remained away all day. The eggs measured and weighed 79.1 by 57.1 mm, 131.4 g, and 76.3 by 55.1 mm, 122.8 g. Both were light blue, unspotted. On 6 August the nest was deserted, the eggs cold, and no cranes seen. The eggs were taken later and sent to the British Museum of Natural History.

Nest 3 On 24 July I found a crane nest back of Sacred Grove (see map) but it was empty. On 9 August I went to the nest and 2 eggs were present. There were 3 the next morning. The nest was in a wet area on a mound. There was much emergent vegetation around it. The water had a pH of 6.64. The nest measured 71.1 by 78.7 cm across and was built of surrounding vegetation. The 3 eggs were 77.0 by 55.4 mm, 122.0 g; 81.8 by 56.6 mm, 136.0 g; and 82.5 by 59.1 mm, not weighed. June Smith checked this nest in early September. The 3 eggs hatched 6-7 September.

Nest 4 On 11 August both cranes were trampling down vegetation, scratching, and working on a nest in a yam patch just west of Kafo. On 14 August it was a neat pile of green grass (now drying) 49 by 51 cm across on a ridge in a rice field, the rice about 61 cm tall. These ridges ran parallel through the rice field. The nest contained 1 light blue, unspotted egg. On 17 August there were 3 eggs, which measured and weighed 79.1 by 59.1 mm, 145.6 g; 78.2 by 59.5 mm, 147.7 g; and 79.5 by 59.9 mm, 149.8 g.

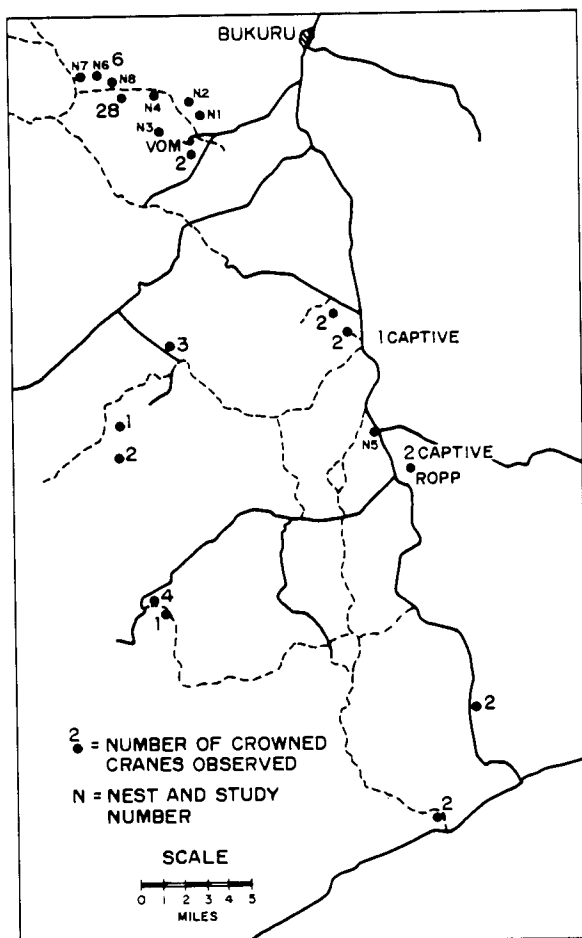


Fig. 1. Crowned crane study area in Plateau Province, northern Nigeria.

Nest 5 On 9 August, C. H. Fry and L. H. W. observed 1 crane in a marsh back of an old tin mine at Barikin Ladi dam. Victor Smith noted a pair there on 15 August. The nest measured 94 by 121.9 cm and was 33 cm above the surrounding water, which was 61 cm deep beside it. It was built in bulrushes of the same material. The pH of surrounding water was 6.78. The 3 eggs measured and weighed 80.2 by 55.8 mm, 135.2 g; 77.7 by 56.5 mm, 135.7 g; and 79.3 by 56.5 mm, 137.9 g.

Nest 6 Nest found 17 August in an atcha field on a dry piece of raised land, built of grass and atcha, depressed some for the eggs. It measured 109.2 by 119.4 cm and was well hidden by the grass and atcha in the vicinity. The 3 light blue eggs measured and weighed 84.0 by 61.4 mm, 168.6 g; 83.2 by 57.7 mm, 148.6 g; and 84.6 by 59.2 mm, 159.9 g. The outcomes of this and nests 4, 5, and 7 were not known.

Nest 7 Nest found 17 August about 305 m from nest 6 and less than 245 m from a nest the 3rd pair was building in the same atcha field, which was grown to atcha and grass. It measured 101.6 by 139.7 cm across and was slightly concave in the center for the eggs. The atcha field was rather damp but not covered with water. There were 2 eggs, light blue, unspotted, which weighed and measured 85.6 by 57.2 mm, 149.6 g, and 85.8 by 58.0 mm, 153.4 g.

During 23 July to 18 August 1965, 72 different wild West African crowned cranes were found in Plateau Pro-



Fig. 2. Crowned crane on nest near Vom, Nigeria.

vince, northern Nigeria, within 755 square miles, but 7 pairs and 34 nonbreeders were found in a much more heavily populated area of 21 square miles and 4 of these pairs were nesting within 2 miles of one another in agricultural fields.

Stanley Crane

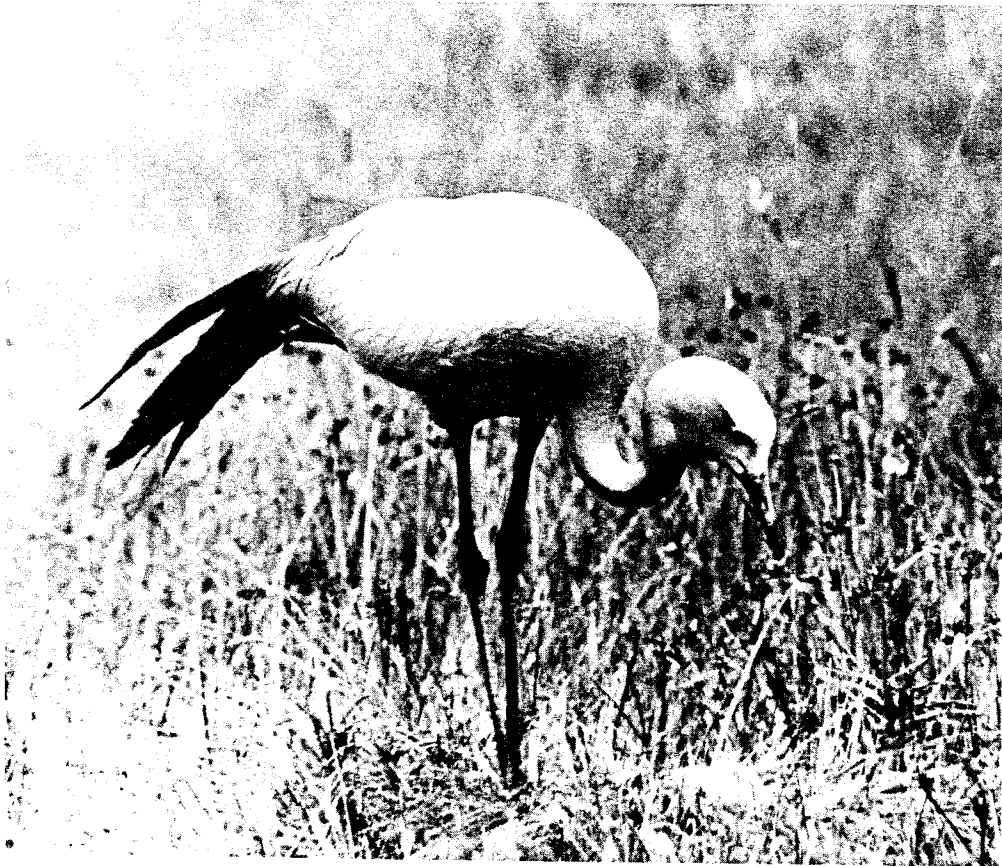


Photo by L. Walkinshaw.

STATUS OF THE BLUE CRANE IN SOUTH AND SOUTHWEST AFRICA¹

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To obtain as much information as possible, a questionnaire was sent to the Department of Nature Conservation in each province and to other interested people. From the answers received and from personal field observations the following report has been compiled.

CAPE PROVINCE

Blue or Stanley cranes (*Anthropoides paradisea*) were present throughout the province, with a special concentration in the Eastern Cape. Flocks containing as many as 200 birds have been reported during the prebreeding season. Nesting occurred between October and January and young birds of different ages were present until May. Depredations on germinating maize occurred during October and November and maize cobs were damaged during March-May. Specific damage was reported from the Districts of Lady Grey and Cathcart. In the District of Cathcart birds were killed by poisoned seed. Shooting was also resorted to, sometimes to kill the birds, but mostly to chase them away.

NATAL

The cranes were found virtually throughout Natal province, except for the coastal districts. Sometimes flocks of up to 100 birds were seen in the prebreeding season. They nested widely in the Magisterial divisions of Underberg, Polela, Mpendhle, Lions River, Mooi River, Umvoti, Escourt, Weenen, Bergville, and Klip River. There were also breeding records in other divisions down to Hlabisa. Some damage was done to newly planted maize, but only during a short period by prenesting flocks. Cranes were occasionally killed by farmers, but this was believed to be of no consequence to the total population.

TRANSVAAL

The Department of Nature Conservation could not submit any information; consequently, the author relied on personal records and those of interested people. There was a fair distribution of cranes throughout the western parts of the province. Flocks of as many as 50 birds were seen in the prebreeding season. Nesting birds were reported during November to January, and young were reported as late as April.

No records of damage to crops were available, and there were no reports of killing these cranes.

ORANGE FREESTATE

Blue cranes occurred practically throughout the province. Flocks of 10 to 300 birds were observed, especially during the prebreeding season. Cranes nested from October to February. Damage to maize, wheat, and lucerne was reported. Gulleets of birds shot by farmers contained up to 250 g of germinating maize or ripe wheat. Flocks apparently damaged germinating maize only during October and damaged wheat just before harvesting. Crane gulleets also contained various insects, and possibly the damage done to farmers' lands was outweighed by the benefit derived from the cranes' feeding on insects harmful to crops. Cranes have been killed with poisoned seed, and more than 200 birds were killed in 1 incident.

SOUTHWEST AFRICA

The cranes were found north of south latitude 20° in Southwest Africa. Concentration of flocks differed from year to year. Nesting adults and young were seen during the summer months in the Districts of Ovambo and Ethosha. Crop depredations by cranes were not reported, and the killing of these cranes either by shooting or poisoning was not reported.

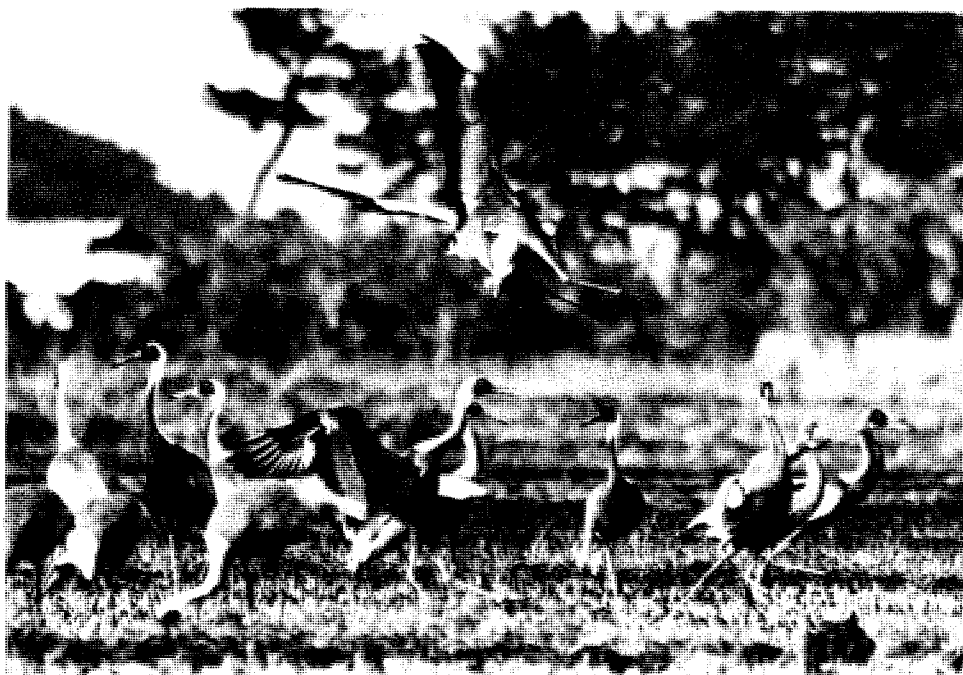
CONCLUSIONS

From the questionnaire responses I conclude that the blue crane population is healthy throughout South and Southwest Africa and is nowhere endangered. In only a few instances was it known that farmers killed birds, either by poisoned seed or shooting, but up to now these losses have posed no threat to the species.

Crop damage is caused by flocks gathering before or after the nesting period. There is, however, a trend developing whereby people keep these birds as pets in their gardens. Consequently, young African natives are encouraged to catch birds of all sizes. The number of cranes accidentally killed during capture or that died due to improper feeding is unknown. It seems, however, that the Department of Nature Conservation personnel are aware of the problem and are not issuing permits to rear cranes captured in this manner.

¹Article written in 1974.

Their Status and Ecology in Some Nations



White-naped cranes (photo by E. Takabayashi).

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CRANES IN CHINA

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There are 15 species of cranes of 2 subfamilies (Gruinae and Balearicinae) and 4 genera (*Grus*, *Buggeranus*, *Anthropoides*, and *Balearica*) in the world. China is blessed with the presence of 8 crane species of 2 genera. We take pride in possessing a majority of the crane species of the world, which fact in itself serves as a stimulus to our work on crane conservation. Among the 8 species, 5 have been definitely recorded breeding within China. *G. leucogeranus* and *G. monacha* probably nested in former times in northernmost China. *G. antigone* has only occasionally been recorded from the southernmost borders of China.

HISTORICAL REMARKS

During the Spring-Autumn period of the West Chou Dynasty (approximately 2,200 years ago) cranes were considered royal birds, and kings of different states used to rear cranes in their palaces. King Hsi-Kung of the Wei State (now in Honan Province) was very fond of rearing cranes and had them trained to dance in a show quite as marvelous as the tail-fan display of peacocks. Furthermore, he had the more experienced cranes appointed as "crane generals." But when the Wei State was invaded by northern enemies the masses refused to fight for the King. The royal army of cranes could only dance and proved to be of no use in driving away the invaders. Despite the collapse of the Wei State, cranes continued to be made royal dancers in the palaces. The emperors or kings thought they would live a long life with cranes dancing on their behalf.

In the Sung Dynasty, Emperor Hui-Zong not only kept crane dancers but was also fond of painting them. His paintings are considered artistic but not entirely accurate because in 1 he had the cranes flying with their necks crooked like those of herons, not straight forward as they should be.

Cranes have traditionally been regarded by the Chinese as symbols of longevity. They are called "sacred" or "fairy" cranes because in fairy tales the immortals are said to ride upon them when going to heaven. According to the Chinese folklore, cranes live 1,600 years. In traditional Chinese paintings the cranes are usually shown among pine trees or bamboo because both types of vegetation also symbolize longevity. As a matter of fact no one has seen cranes living in trees or bamboo groves.

DISTRIBUTION IN CHINA

Among the 8 species of cranes found within China, all are migratory except *G. antigone* which is only occasionally recorded from Yunnan. I have attempted to assemble all the available data, though quite scanty, concerning the cranes' distribution in China (Cheng 1976). A synopsis is given here together with some newer records.

G. g. lilfordi breeds in Hulungboir Meng of the Mongolian Autonomous Region and Tianshan in Xinjiang Autonomous Region. They migrate from North China to winter in South China. *G. monacha* was formerly recorded nesting in northern parts of Heilungjiang Province (Meise 1934), but not in recent years. The species migrates along the coastal provinces to winter in the Lower Yangtze Valley. This crane has been seen

during spring and autumn migrations along the Lower Wu-yu-er River near Qiqihar of Heilungjiang Province.

G. japonensis nests on Hulunboir Meng marshlands of Mongolian Autonomous Region, from Zha-loung Fishery Grounds (in the southeastern suburbs of Qiqihar) eastwards to the San Jiang Plains of Heilungjiang Province, and also in Bai-cheng District of Jiling Province. They migrate along the coastal provinces to winter in the Lower Yangtze and southeastern China, occasionally also in Taiwan Province. *G. vipio* nests in the Lower Wu-yu-er River of Heilungjiang Province and Tong-yu District of Jilin Province. They migrate along the coastal provinces to winter in the Lower Yangtze, and occasionally in Fukian and Taiwan Provinces.

G. leucogeranus was formerly recorded breeding in Hulungboir Meng of Mongolian Autonomous Region and Qiqihar of Heilungjiang Province, but not in recent years. They migrate along the Wu-yu-er River and Nen-jiang River in central parts of Heilungjiang Province and also southward along the coastal provinces. According to LaTouche (1934), Przewalski had seen the bird in Qinghai Lake. This species has declined sharply recently and we have failed to locate them in the wintering grounds along the Lower Yangtze.

G. nigricollis nests around the margins of upland marshes and on islands of lakes in the steppes of Qinghai Province and northwestern Sichuan. They migrate throughout Qinghai-Xizang Plateau to winter in southern Sichuan, western Guizhou, Yunnan, southern Xizang, and regions farther southward. It is the world's only alpine crane species, nesting at an elevation of 3,500 to 5,000 m. It is also the last of the world's crane species to be discovered (in 1876). For further information concerning the migrating and wintering of the black-necked crane the reader is referred to Archibald and Oesting (1981). For data on breeding see Lu et al. (1980).

G. antigone is only occasionally reported from the southernmost borders of Yunnan Province. *Anthropoides virgo* nests in Hulungboir Meng of Mongolian Autonomous Region, Qiqihar of Heilunjiang Province, and Tian Shan in western Xinjiang Autonomous Region. They migrate from North China, Qinghai Province in northwestern China, and southern Xizang to winter in Burma, India, and westward to eastern Africa.

NUMERICAL STATUS

To the best of my knowledge, Hemmingsen (Hemmingsen and Guildal 1968) is the only person who has made long-term observations of migrating cranes. The data are out of date, but total numbers are listed here for reference (Table 1). Concerning *G. nigricollis*, a migrating flock of about 300-400 cranes were seen by our collecting team in September 1973 at the Tangra Range Pass (about 5,000 m altitude) flying southward. In mid-October 1979 a flock of at least 600 cranes was seen in Nuomubong in the Tsaidam Basin. *A. virgo* are quite common in northern China, though no census has been made.

From Table 1 it is evident that *G. g. lilfordi* is the most common of the cranes in China, with *A. virgo* probably ranking 2nd. The black-necked cranes are not

Table 1. Cranes observed migrating over Bei-dai-he Beach, Hebei Province, China (Hemmingsen and Guildal 1968).

Species	Recorded during migration	
	Spring	Autumn
<i>G. g. lilfordi</i>	4,250 (1943-45)	20,139 (1942-45)
<i>G. japonensis</i>	90 (1943-45)	353 (1942-45)
<i>G. monacha</i>	60-100 (1943)	170-300 (1942-45)
<i>G. vipio</i>		46 (1944-45)
<i>G. leucogeranus</i>	600-700 (1945)	357 (1943-45)

4. Artificial propagation--breeding of captive cranes and maintenance of species "banks".
5. Research in nutrition, rate of fecundity, reduction of mortality, prevention of contagious diseases, chromosome analysis, exchanges of gene pools, and hybridization of different populations.
6. The public should be educated about the importance of conservation of nature and natural resources to insure a more favorable ecosystem for mankind in present and future.

as rare as formerly believed, but they are mostly confined to Qinghai-Xizang Plateau. They have probably been protected by the Buddhist faith. Preliminary studies have been made of breeding populations of *G. japonensis* at Zha-loung in Heilungjiang Province (Ma and Zu 1980) and *G. nigricollis* at Lonbaotan in Qinghai Province (Lu et al. 1980). Results are listed in Table 2.

CONSERVATION MEASURES

Crane populations in China have steadily declined. This decline is mainly due to the complete land utilization resulting in a large-scale alteration of habitat, especially along the Lower Yangtze Valley. Excessive hunting of cranes, especially by netting, is also a causative factor. The following conservation measures should be initiated because of the population decline.

1. The effective enforcement of game laws.
2. Habitat management and conservation of land and vegetation on breeding and wintering grounds.
3. Establishment of crane refuges (2 sanctuaries have already been established, 1 for *G. japonensis* at Zha-loung in Heilungjiang Province, and the other

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Table 2. Preliminary surveys of breeding populations of *Grus japonensis* at Zha-loung, Heilungjiang Province (Ma and Zu 1980) and *G. nigricollis* at Lonbaotan, Qinghai Province, China (Lu et al. 1980).

Species	Breeding area (km ²)	Cranes	Cranes per km ²
<i>G. japonensis</i>	169.5	122 ^a 115 ± 47 ^b	0.7
<i>G. nigricollis</i>	45.0	c	1.45 (mid-April to mid-May) 0.76-0.78 (June)

^aBy sampling method.

^bBy line transect method.

^cDirect counting from fixed location.

CRANES OF THE MONGOLIAN PEOPLE'S REPUBLIC

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Except for the taxonomic list of birds of the Mongolian People's Republic (MPR), there are no specific publications about cranes living there. Six species have been recorded in Mongolia: common (*Grus grus lilfordi*), red-crowned (*G. japonensis*), white-naped (*G. vipio*), Siberian white (*G. leucogeranus*), hooded (*G. monacha*), and demoiselle (*Anthropoides virgo*) (Fig. 1). Among the 6 species *G. leucogeranus* is the most rare, a migrant. There has been 1 recent sighting made 1 May 1958 near the city of Ulan-Bator.

G. monachus is a fairly common migrant. In groups of 2, 3, up to 5 it is regularly encountered beginning about 10 April, on the eastern edge of the Hangai upland, with huge flocks of migrating *G. grus*. *G. japonensis* has been sighted in easternmost MPR in the Halhin River basin. They are a rare and irregular migrant. *G. vipio* is a common but not numerous nesting species found throughout the forest-steppe zone of eastern Mongolia, from the Halhin River to the headwaters of the Kerulen River.

G. Grus is a numerous migratory species. The first flocks are usually sighted at the end of March. Spring migration continues through the first 10 days of May. Separate small flocks have usually been sighted at Lake Har-us (western Mongolia) and in the valley of the Orhon.

A. virgo is a very common, widely distributed, and numerous nesting species, inhabiting all the steppe and forest-steppe zone of MPR. They first appear at

the end of April. In mid-May they nest in dry uplands and have a clutch of 1-2 eggs. Chicks hatch about 18-20 June. I believe that the population of *A. virgo* in MPR is the largest in the world. Cranes are not hunted in MPR, and this is favorable for the increase of numbers of these birds, among the rarest of the world's fauna.

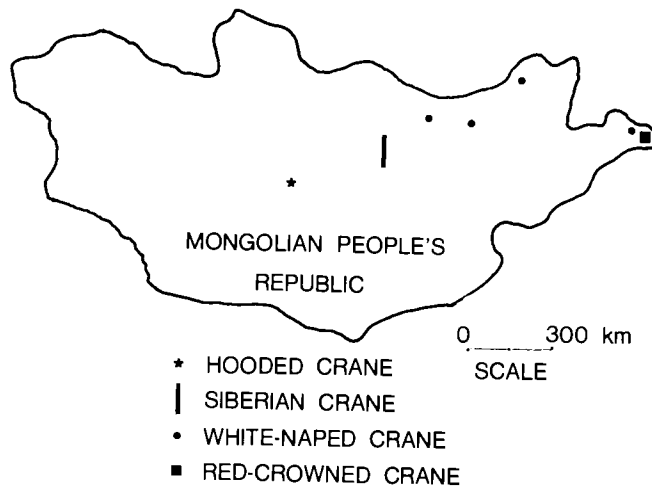


Fig. 1. Distribution of cranes in the Mongolian People's Republic.

WILD AND CAPTIVE CRANES IN JAPAN

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I will discuss the past and present status of wild and captive cranes in Japan and will be pleased if this report helps you understand the cranes of Japan.

CRANES IN THE WILD

There are 2 categories of cranes in the wild in Japan: resident species and migratory species. The resident crane species is the red-crowned (*Grus japonensis*) and the migratory species are the hooded (*G. monacha*), white-naped (*G. vipio*), common (*G. grus*), Siberian white (*G. leucogeranus*), sandhill (*G. canadensis*), and demoiselle (*Anthropoides virgo*). Before 1869, when the Government of Meiji was founded, there were many wild cranes wintering in Japan. But within about 25 years, due to hunting before the hunting law was enacted in 1892, almost all the wild cranes disappeared from Japan except in some very restricted places.

G. japonensis was once thought to be extinct in Japan, but in 1924 some were discovered nesting in Kushiro District, Hokkaido. In 1935 they were designated as a natural monument by the government. The population was then estimated to be about 20-30.

In 1952 it was very cold in Kushiro District and the cranes left the marshes and flew to cultivated fields for food. The restricted areas of open waters, where the cranes usually found food in winter, were all frozen. The people of Kushiro, including school children, began to feed them. Hearing of the crisis among cranes, many people in Hokkaido and all over Japan assisted the people of Kushiro, donating food and money, and thus the cranes survived this unusually cold winter.

The next winter was not as cold as that of 1952, but the cranes again came to the cultivated fields and

Table 1. Numbers of wild *Grus japonensis* in Hokkaido, Japan, 1952-1979.

Year	Number	Year	Number
1952	33	1966	170
1953	42	1967	200
1954	52	1968	171
1955	61	1969	212
1956	76	1970	179
1957	92	1971	147
1958	125	1972	222
1959	139	1973	233
1960	172	1974	253
1961	175	1975	194
1962	184	1976	220
1963	147	1977	257
1964	154	1978	214
1965	172	1979	271

the people gave them food as they had the previous winter. Thereafter the cranes returned to the villages each winter and the number of cranes increased each year. In the winter of 1979, 271 cranes were counted during the census. But the cranes are artificially fed in winter, although they live in the wild. They do not migrate as before and also their habitats may not be safe because of possible future changes (Table 1).

The Migratory Cranes

A small number of *G. monacha* come to Yashiro Village, Yamaguchi Prefecture, and about 4,000 cranes including *G. monacha*, *G. vipio*, and small numbers of other species mentioned previously, come to Sendai City (Arasaki), Kagoshima Prefecture, every winter. They are designated as natural monuments by the government and are also artificially fed. There are so many cranes concentrated in a small area, especially in the rice fields, that it causes problems with the farmers. Some infectious diseases of cranes, which may break out some time in the future, are also a threat. Tables 2 and 3 indicate the species and numbers of cranes which have migrated to Japan for the past 50-80 years.

CRANES IN CAPTIVITY

We have many zoos in Japan and several species of cranes are kept there because they are important birds to display. The species of cranes and numbers present in zoos in Japan in 1973 were previously reported (Koga 1975:Table 5). Table 4 lists the cranes which were produced in Japanese zoos from 1969 to 1977. Usually cranes lay 2 eggs a year in the wild. I have previously reported that in captivity I can stimulate production of eggs by a female by removing eggs from the nest after they are laid (Koga 1976). Although all of them were not fertile, the maximum production

Table 2. Numbers of *Grus monacha* migrating to Yashiro Village, Yamaguchi Prefecture, Japan, 1897-1979.

Year	Number	Year	Number
1897	35	1968	78
1907	55	1969	71
1912	65	1970	91
1921	100	1971	108
1933	140	1972	106
1940	355	1973	130
1945	250	1974	101
1950	160	1975	106
1955	150	1976	108
1960	132	1977	106
1965	101	1978	73
1966	125	1979	89
1967	65		

Table 3. Cranes that migrated to Sendai City, Kagoshima Prefecture, Kyushu, Japan, 1927-1978^a.

Year	G.c.	G.g.	G.j.	G.l.	G.m.	G.v.	A.v.
1927					400	40	
1929		1			600	100	
1936		2	1		2,381	158	
1939		3	1		3,435	469	
1947					250	25	
1950					265	28	
1955					274	25	
1960		1		1	376	60	
1961					723	71	
1962		2			811	96	
1963	1				1,053	95	
1964		3			1,127	121	
1965		2			1,442	129	
1966					1,447	181	
1967		5	1		1,450	221	
1968		5			1,452	203	
1969		3			1,562	233	
1970		3			2,072	257	1
1971		2			2,023	287	1
1972		2			2,286	401	
1973	1	2			2,793	449	
1974		4			2,157	582	1
1975	1				2,867	781	
1976		1			2,701	732	
1977 ^b	1	1			3,296	1,220	
1978 ^b		1			3,179	1,448	

^aG.c. (*Grus canadensis*), G.g. (*G. grus*), G.j. (*G. japonensis*), G.l. (*G. leucogeranus*), G.m. (*G. monacha*), G.v. (*G. vipio*), A.v. (*Anthropoides virgo*).

^bG.g. × G.m. hybrids, 3 individuals wintered in 1978.

in 1 year was 8 eggs by *G. japonensis* and 16 eggs by *G. vipio*.

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Table 4. Cranes hatched and reared in Japanese zoos, 1969-1977.

Species	1969	1970	1971	1972	1973	1974	1975	1976	1977
<i>G. antigone</i> at 13 zoos		3	7	3	3	7	7	4	3
<i>G. grus</i> at 2 zoos			1	1	1	2	2	1	2
<i>G. japonensis</i> at 4 zoos	1	1					3	3	4
<i>G. vipio</i> at 2 zoos	1	1	1	1		1		1	1
<i>A. paradisea</i> at 3 zoos				1	3	5	6	8	3
<i>Balearica pavonina</i> at 4 zoos		3	2		3	6	1	2	1
<i>B. regulorum</i> at 9 zoos	2	5	3	4	4	5	12	8	7

WINTERING LIFE OF CRANES IN KAGOSHIMA AND YAMAGUCHI PREFECTURES, JAPAN

SATOSHI NISHIDA, 6-12 Kamifujimatsu 2-Chome, Moji-Ku, Kitakyusya

Formerly cranes visited many districts in Japan as is mentioned in old Japanese anthology. But now they are found only in Izumi, Kagoshima prefecture; Yashiro, Yamaguchi Prefecture; and Hokkaido. Izumi, situated in southwestern Kyushu, is rather cold in winter, though it is located in southern Japan. In the Edo Period, Izumi was established as a game preserve by the Lord of Shimazu. In 1921 the cranes were designated as a Natural Monument. Yashiro, situated in southwest Honshu, is also cold in winter because it is located on a high tableland, 320 m above sea level. Cranes have visited Yashiro since the Edo Period and were designated as a Natural Monument in 1921.

I and my coworkers have been studying cranes in Izumi and Yashiro for more than 20 years. This report describes their wintering life, which has been made clear through our ecological and ethological studies.

SPECIES AND POPULATIONS

In Izumi, 7 species (hooded [*Grus monacha*], white-naped [*G. vipio*], Siberian white [*G. leucogeranus*], red-crowned [*G. japonensis*], common [*G. grus*], demoiselle [*Anthropoides virgo*], and sandhill [*G. canadensis*]) have been observed. The Siberian white crane was observed twice (1959-60 and 1960-61) and the red-crowned crane once (in 1967-68). Population numbers in this decade are shown in Table 1. Compared with the 421 in the winter population in 1959-60, their population increase is astonishing.

In Yashiro 3 crane species (hooded, common, and white-naped; the latter seen in 1972-73), have been observed (Table 2). Their numbers are stable and never exceeded 150 in this decade. The population differences between Izumi and Yashiro can be explained by the carrying capacity of the site they live in.

TERRITORY

It is well known that cranes establish territories during the breeding season. They also often try to maintain territories after they migrate to the wintering habitat. We studied their territories in Izumi for 3 winters (1966-67 to 1968-69). Fig. 1 shows the area studied and distribution of territories observed

in 1967. The fields occupied by cranes are those in which rye, wheat, or rape are planted. The data obtained show that the size of a territory is 20 to 300 m² and averages about 100 m². The size of a territory seems to be influenced by the population density of the area or the area of standing crops available.

HYBRIDS

A mixed-species pair of hooded crane (male) and common crane (female) was observed in Izumi for 7 years (1968-69 to 1974-75). During this period (except 1973-74) they had 7 hybrid chicks and maintained a territory in Euchu. This is evidence that cranes annually use the same territory. Grown-up hybrids were observed as follows: 1 on 22 November 1971, 1 on 24 November 1972, 1 on 10 March 1975, and 3 during 1978-79.

FLOCK AND FAMILY COMPOSITION

Flocks of cranes are seen frequently. Table 3 shows examples of flocks and the average proportion of juveniles. The number of hooded cranes observed is rather small because territorial families are not included in these flocks. The ratio of crane pairs with 2 young to pairs with a single young was 48:52 among hooded cranes in 1966-67. Among white-naped

Table 1. Populations of cranes wintering at Izumi, Japan, 1970-1979 to 1979-1980.

Year	Cranes					Total
	Hooded	White-naped	Common	Sandhill	Demoiselle	
1970-71	2,072	257	6	0	1	2,336
1971-72	2,023	287	2	0	1	2,313
1972-73	2,286	401	2	0	0	2,689
1973-74	2,793	449	2	1	0	3,245
1974-75	2,158	582	4	0	1	2,745
1975-76	2,867	781	0	1	0	3,649
1976-77	2,813	1,021	2	0	0	3,836
1977-78	3,296	1,220	1	1	0	4,518
1978-79	3,179	1,448	3 ^a	0	0	4,631
1979-80	3,889	670	4	1	0	4,564

^aHybrids.

Table 2. Populations of hooded cranes wintering at Yashiro, Japan, from 1970-1971 to 1979-1980.

Year	Population number	Arrival date	Number					Date of departure
			Oct	Nov	Dec	Jan	Feb	
1970-71	91	27 Oct	34	20	37	0	0	15 Feb-1 Mar
1971-72	108	20 Oct	11	30	67	0	0	7 Mar-15 Mar
1972-73	104	24 Oct	4	61	20	0	19	28 Feb
1973-74	134	30 Oct	4	94	36	0	0	21 Feb-8 Mar
1974-75	90	23 Oct	37	0	46	2	5	2 Mar-12 Mar
1975-76	108	28 Oct	7	39	30	32	0	6 Mar
1976-77	110	26 Oct	19	13	53	10	15	10 Mar-12 Mar
1977-78	105	3 Nov	0	46	8	51	0	1 Feb-5 Mar
1978-79	87	23 Oct	11	22	21	27	6	7 Mar-16 Mar
1979-80	73	7 Nov	0	22	49	2	?	?

cranes observed 2 January 1980 the ratio was 27:73.

FOOD HABITS AND FORAGING BEHAVIOR

The food habits of the hooded crane are not well known. A study of fecal pellets and observations through telescopes in Yashiro in 1973-74 indicated that hooded cranes foraged mainly on unhulled rice from late October to the beginning of December and later fed on wheat and barley (Table 4).

Standing crops available to cranes as food were studied in Yashiro 1972-1973 and 1973-74. Forty soil

samples (1/16 m² and 10 cm in depth) were collected in Yashiro and Mitsuo where cranes forage and from Susuman where cranes are not found. Seeds and other potential crane foods present in the soil were counted. Data from Yashiro are shown in Table 5.

Crane foraging activities were studied in Yashiro. Time spent foraging by cranes was measured with a stop-watch and frequency of swallowing was counted. A pair that had 1 juvenile was observed; each of the latter cranes was studied simultaneously. Total time of the observations was more than 11 hours in 2 days. Both adults spent a similar amount of time searching

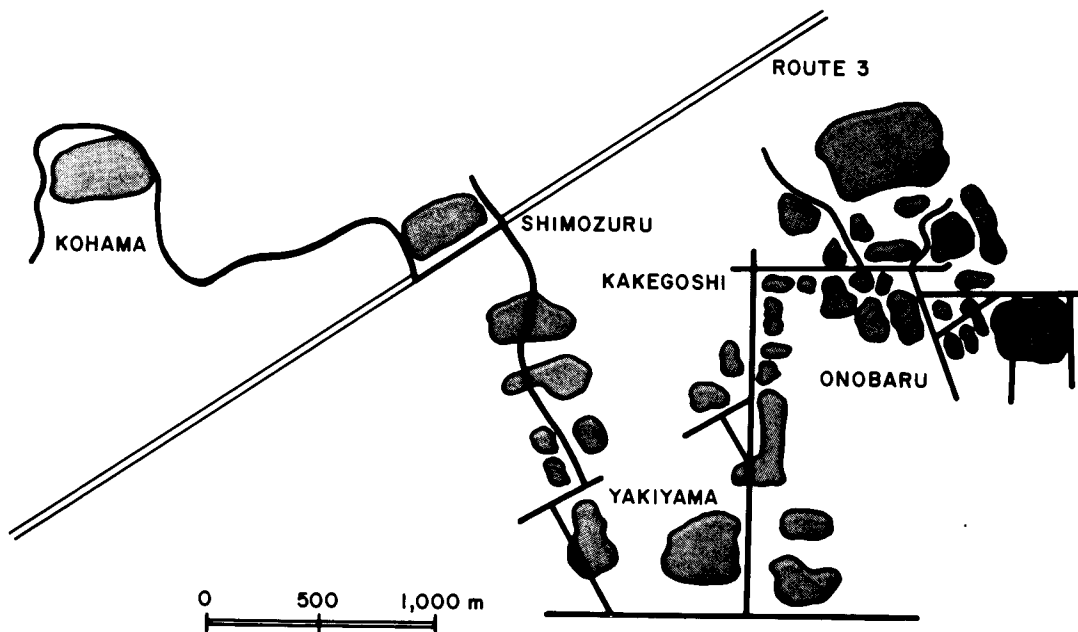


Fig. 1. Configuration of winter territories of cranes at Izumi, Japan, January-February 1967.

Table 3. Percentages of juveniles in flocks of hooded and white-naped cranes at Izumi, Japan, 1968-1972.

Hooded cranes			White-naped cranes		
Date	Flock size	% juveniles	Date	Flock size	% juveniles
9 Nov 1968	750	20.0	29 Dec 1968	166	14.5
1 Nov 1969	255	18.8	31 Dec 1968	84	4.7
28 Dec 1969	144	13.2	29 Dec 1969	130	13.8
31 Dec 1969	543	13.6	2 Jan 1970	225	15.5
1 Jan 1971	428	11.7	30 Dec 1970	198	16.2
3 Nov 1971	183	16.4	1 Jan 1971	255	18.4
21 Nov 1971	140	8.6	23 Nov 1971	61	27.8
21 Nov 1971	285	8.9	30 Dec 1971	295	8.8
28 Dec 1972	256	2.0	28 Dec 1972	182	23.1
3 Nov 1971	132	5.4	31 Dec 1972	230	20.4
Total	3,107	13.5	Total	1,826	16.0

Table 4. Contents of crane fecal droppings and the (frequency of occurrence of) food items during various winter periods, Yashiro, Japan, 1974.

Sample size and food item	Nov	Early Dec	Late Dec	Jan	Total
Number of droppings	21	34	49	8	112
Rice hulls	21 (100.0)	34 (100.0)	25 (51.0)	2 (25.0)	82 (73.2)
Seeds	3 (14.3)	0	1 (2.0)	0	4 (3.6)
Grit	7 (33.3)	6 (17.6)	6 (12.2)	2 (25.0)	21 (18.8)
Grass fragments	4 (19.0)	9 (26.5)	14 (28.6)	3 (37.5)	30 (26.8)
Shell fragments	1 (4.8)	1 (2.9)	2 (4.1)	0	4 (3.6)
Insects	0	2 (5.9)	2 (4.1)	0	4 (3.6)
Wheat or barley husks	0	1 (2.9)	33 (67.3)	6 (75.0)	40 (35.7)
Unidentified materials	0	20	37	6	63

Table 5. Food items (average per m²) presumed available to cranes in upper soil layer, Yashiro, Japan, 1974.

Food item	Early Nov	Mid-Nov	Dec	Jan	Average
Rice seed	8	52.6	28	32	29.2
Rice hull	140.5	411.4	28	58.7	157.9
Barnyard grass seeds	32	2.3	0	0	9.4
Tubers	24	48	2	61.3	31.4
Grass roots	0	0	2+	5.3+	1.7+
Earthworms	0	2.3	4	0	1.7
Snails	8	2.3	2	0	3.3
Leeches	6	0	0	0	1.7
Spiders	8	0	0	0	0.6
Frogs	0	0	0	2.7	0.6
Larvae	0	4.6	6	16	6.1

for food (Table 6). The juvenile spent more time searching for food but swallowed less frequently.

ROOSTS AND ROOSTING BEHAVIOR

Roosts used by cranes have specific characteristics. The roosts need to be isolated from disturbance by men and animals. Shallow water is needed because cranes prefer to sleep standing in water to protect themselves from predators. In Izumi almost all the cranes, more than 1,000, roost at 1 location, but hooded cranes and white-naped cranes roost separately.

In contrast, in Yashiro more than 20 roosts have been found. Each roost contains a small group or a family unit. A roost was created there by cultivating and irrigating a wasteland and subsequently the cranes used it constantly.

Cranes leave their roosts at daybreak. The relationship between lux and roosting behavior was studied in Yashiro in 1973-74. Cranes are very sensitive to light intensity, although they can see in the dark. Figure 2A indicates that roosting behavior is determined by light. Light between 0 and 20 luxes stimu-

lates movement to or from the roost (Fig. 2B).

PROBLEMS PROTECTING CRANES

Historically, cranes in Izumi and Yashiro have been protected by local farmers. Farmers were tolerant of crop damage caused by cranes. But with the passage of time the farmers' attitudes have changed. Several years have passed since the problems about cranes arose in Izumi. When cranes are present farmers dare not plant their fields in winter. Very little indemnity is paid to farmers by the government. Many sightseers come by car to view cranes and are a noisy nuisance. The farmers receive no benefit from the cranes, thus cranes have become unpopular with the farmers. Local farmers can preserve the cranes, not legislation. Some actions are to be taken to solve these problems in the near future.

Another problem is artificial feeding stations. As I have described, the cranes' territories were widely distributed in Izumi District; but with increased population, the cranes tend to assemble at feeding stations and spend the entire day there. I am concerned that this behavior will destroy the ecology of cranes.

Table 6. Amount of time that a hooded crane family spent feeding and the frequency of swallowing, 10-11 February, 1975, Yashiro, Japan.

	Time segment					Average
	0700-0900	0900-1100	1100-1400	1400-1600	1600-1800	
Male						
Frequency of swallowing	1,469	142	386	502	1,395	793
Time feeding ^a	32' 09"	15' 17"	25' 03"	18' 33"	30' 29"	26' 30"
Female						
Frequency of swallowing	2,122	154	296	679	1,271	897
Time feeding	41' 15"	15' 04"	16' 21"	36' 36"	31' 13"	26' 39"
Juvenile						
Frequency of swallowing	1,132	102	245	523	937	579
Time feeding	33' 13"	36' 00"	33' 21"	37' 01"	41' 13"	36' 21"

^aMinutes and seconds per hour observed.

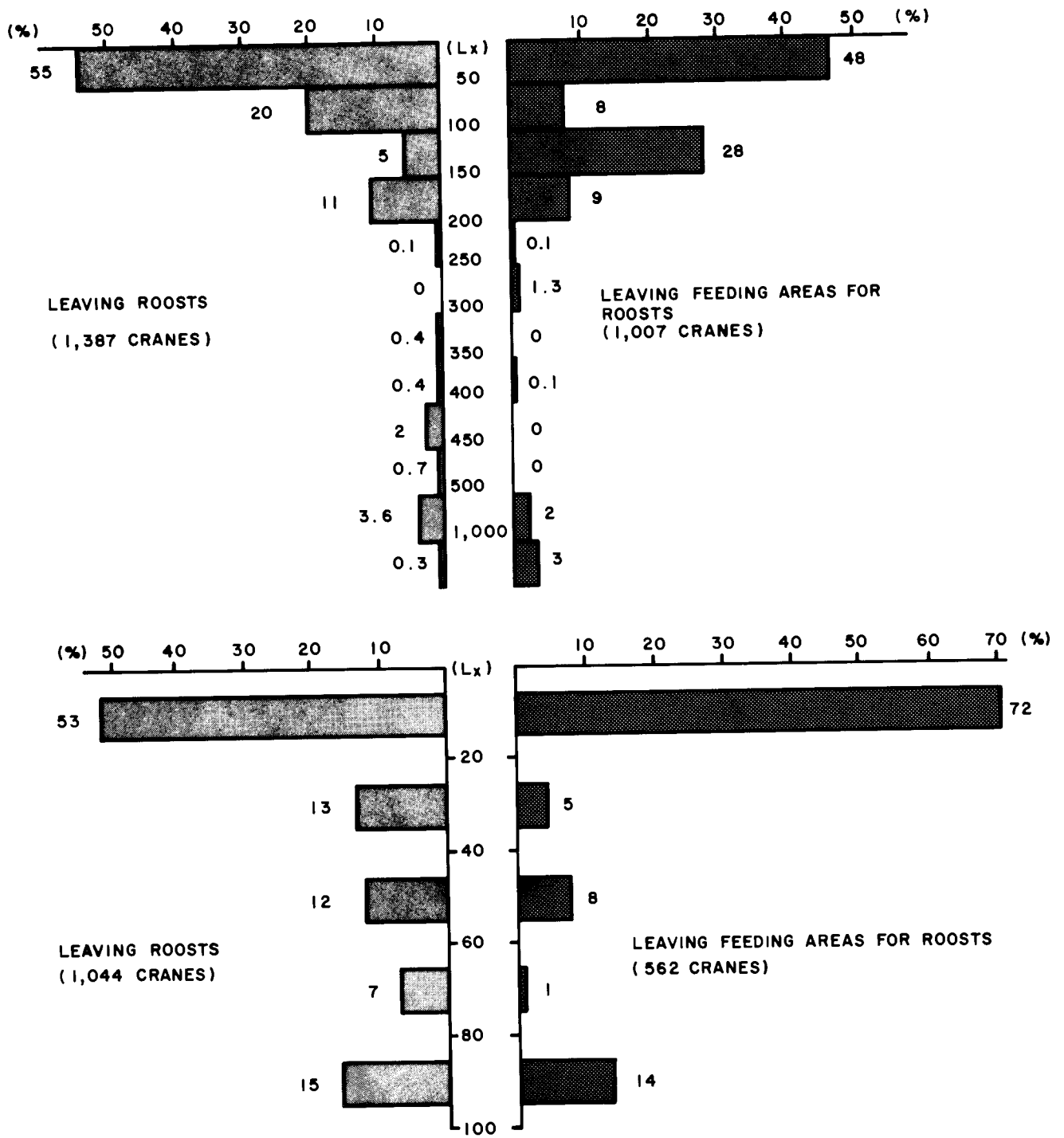


Fig. 2. Relationship between lux and roosting behavior of cranes at Yashiro, Japan, November 1973 through February 1974.

CRANES IN KOREA

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About 50 years ago, red-crowned cranes (*Grus japonensis*) were found throughout Korea and it was common to see their graceful flights in the moonlight. Today, due largely to man's activities, these cranes are much scarcer. The increasing human population has precipitated a need for increased food supplies and the ancient marshlands in Korea, as elsewhere in the Orient--indeed throughout the world, are being drained for agriculture. Three species of cranes are found in Korea; the white-naped (*Grus vipio*) is the most common. The white-naped cranes only winter here. The red-crowned is found in only very small numbers, but is a regular winter visitor. The hooded crane (*G. monacha*) is uncommon, but some are sighted in migration almost every year.

SURVEY STATUS

No complete survey for cranes has ever been made in the Korean peninsula. However in 1962, the senior author undertook a partial survey in connection with a documentary film on birds wintering in the southern portion of the peninsula. In the winter of 1973-1974, with the aid of the International Crane Foundation and the New York Zoological Society, a slightly larger winter survey of cranes was undertaken in the Republic of Korea (South Korea), beginning 2 November 1973 and ending 18 April 1974¹.

DISTRIBUTION

Data from the Korean peninsula concerning the distribution of the 3 crane species--*monacha*, *vipio*, and *japonensis*--are very limited (Fig. 1). The winter distribution of the hooded crane in Korea is especially unclear. According to Austin (1948) this crane was "not uncommon," usually arrived in late November-early December, a month after the white-naped crane, and left in February, earlier than the other cranes. The largest flock reported (about 200) was seen near Suwon 10 February 1946. Suwon is in Kyonggi Do Province just southwest of Seoul (Fig. 1). *Grus monacha* has been reported several times in Kyonggi Do Province; however, the 1973-1974 survey did not detect any along the Han River Kyonggi Do Province.

In North Korea (Democratic Peoples' Republic of Korea) hooded cranes have been reported in winter from South Hwanghae, South Hamgyong, and South Pyongan Provinces, but these records are quite old (1911-1932) and more recent information is lacking.

In South Korea, *G. monacha* has appeared in 5 other provinces in addition to Kyonggi-Do Province near Seoul. The greatest number of reports (1915-1930) were from South Cholla Province at the southwesternmost tip of the Korean peninsula. Single reports come from South Chungchong and North Kyongsang Provinces. From the southeasternmost province, South Kyongsang, there is only 1 published report but in 1970 one was captured there. On a visit to the Nakdong River bird sanctuary in February 1974, in South Kyongsang Province, cranes were not seen. A central province, North Chungchong, from which there are no previous reports, had 1 *G. monacha* captured in February 1974.

The reports of *G. monacha* are extremely sparse and the locations of its wintering grounds and the numbers of birds involved are unknown.

Simultaneous with the apparent decrease of *G. monacha* in Korea, the number of winter migrants of this species to southern Japan has increased remarkably. Cranes have been counted since 1947 at the Arasaki feeding station in Kyushu. Between 1947 and 1952 crane numbers decreased slightly but since the feeding program began the numbers have steadily increased. Except for 6 years in the past 2 decades, the average increment in numbers was 25 birds.

However in 1961, 1963, 1964, 1970, 1971, and 1972, the average annual increase in numbers was 308 (Kuroiwa 1973, pers. comm.). This increase is much too high to have been caused by productivity from the previous year's recorded breeding population. Possibly the increase can be attributed to *G. monacha* that had been wintering in Korea but now migrate southward to Japan, thus explaining the lack of *G. monacha* reports in Korea in recent years.

The situation is scarcely better for the other 2 species--red-crowned and white-naped cranes. The red-crowned crane is listed by Austin (1948) as being more frequently found in Korea than hooded but less frequent than white-naped. The numbers of wintering red-crowned cranes have, however, declined considerably; there can be no doubt about that. Apparently red-crowned cranes prefer habitats slightly north of those of the other 2 cranes in Korea. Taczanowski (1888) reported them as "common in winter from the Russian frontier to Seoul, rare farther south."

The red-crowned crane has been reported from time to time throughout the Korean peninsula, arriving with the hooded cranes in early December. The province of South Hwanghae, in southwestern North Korea, where there are numerous hot springs and mudflats along the coast, appears to be the traditional center of distribution of wintering red-crowned cranes. Whether or not these birds winter there since the war is unknown, but Masatomi and Kitagawa (1974) cite 1 unconfirmed report that this may still be a major wintering area for *G. japonensis*. There have been some reports from the province of Kangwon Do in North Korea and from every province of South Korea, including Chejudo, or Quelpart Island, off the southern coast. The lower-lying west and south coasts seem generally preferred by these birds, with scattered wintering areas also present in the interior. Postwar sightings include 12 north of the city of Kangnung in Kangwon-Do Province and approximately 12 were found in the 1973-1974 winter survey along the Demilitarized Zone (DMZ) near Panmunjom.

The white-naped crane is the 1st to arrive in winter, in late October-November in Kangwon Do Province of North Korea. As winter progressed many used to continue their journey southward and concentrated by the thousands in the interior province of North Chungchong (Kuroda 1937). Another major concentration of these birds used to be at South Hwanghae, where, when the weather grew severe, they congregated in the hot springs areas or moved farther south to North and South Chungchong Provinces (Mori 1938).

¹Article written in 1974.

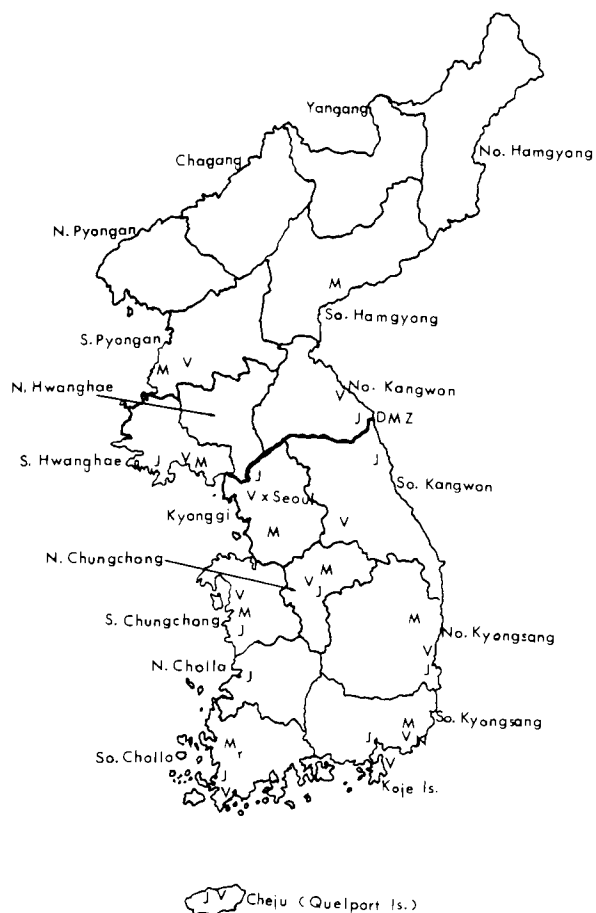


Fig. 1. Crane sighting locations listed by provinces in North and South Korea (V = *G. vipio*, M = *G. monacha*, J = *G. japonensis*).

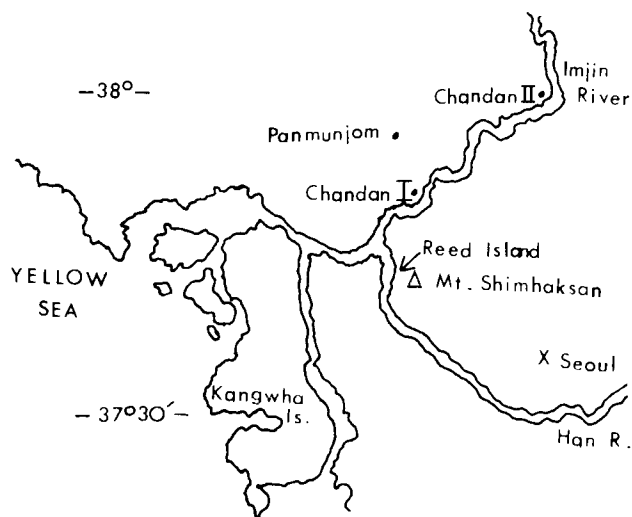


Fig. 2. Winter crane survey area in South Korea and the Demilitarized Zone, 1973-74.

Unlike red-crowned cranes, white-caped cranes have never been reported from the hillier eastern coast. White-naped cranes have been reported, however, from all along the south and west coasts of South Korea, including Koje and Quelpart Islands. In the south-westernmost province, South Cholla, they were once so deleterious to crops that hunting was allowed (Mori 1938). The populations of white-naped cranes have also declined from former times.

1973-1974 SURVEY

Because of the limited amount of time and money available for the 1973-1974 survey, efforts were concentrated along the western edge of the DMZ and the area along the Han River (Fig. 2) where cranes were known to winter. Villagers along the Han River reported that cranes have spent the winter there for many, many years, although there were few of them during the years of the Korean war. Indeed, the major concentration of wintering cranes seems to be a large reed island in the Han River near Mount Shimhaksan (193 m), whose very name means "Seeking Cranes" (the syllable "hak" means "crane").

This reed island is winter home to white-naped and red-crowned cranes and also serves as a staging area for white-naped cranes during fall and spring migration. Approximately 38 white-naped cranes spent the entire winter of 1973-1974 using this island as their roosting area. They would fly about the countryside during the daytime to feed and then return to the roost at dusk. Sometimes they would feed along the Han River near the roost.

The total number of cranes that used the Han River area as a fall staging ground is unknown because the survey could not begin when birds were first arriving. However, on 14 November, the 1st day of survey in that location, there were 314 birds present along the Han River. A week later (22 November) there were only 38 birds left wintering on the reed island. In spring, however, the 38 cranes were all counted on 12 March and suddenly on 13 March, there were some 350 birds along the Han River. The numbers increased throughout the week, and by 22 March there was a flock of over 1,000 white-naped cranes present. This large number was particularly encouraging because, before this count, it was believed that there were only a few hundred wild white-naped cranes left in Korea. The numbers present decreased to only 110 birds on 4 April and by 18 April we could count only 10.

During winter the greatest number of red-crowned cranes counted in any single area was 8 birds. These cranes were counted at 3 different locations: at Chandan I and at Chandan II along the Imjin River, and at Panmunjom in the DMZ. At Chandan I, 3 were generally seen (perhaps a pair with a yearling chick). At Chandan II there were generally either 3 birds or just 1 (possibly a pair and another single adult). At Panmunjom there were usually either 2 or 4 birds (likely 2 pairs). We estimate there were about 12 of these cranes throughout the winter along and just south of the DMZ. Hooded cranes were never seen in the 1973-1974 winter survey.

MIGRATION

Are the few red-crowned cranes that wintered in the DMZ, and just south of that zone, migratory birds? Although Taczanowski (1893) listed them as nesting in Korea, no record has ever been confirmed. But the small population observed in winter might indicate a sedentary population. The 1972 survey of this species

in Hokkaido, Japan (Archibald 1972) indicated that indeed the species is not always migratory and a flock of only 12 birds seems very small to be a migratory group. Perhaps these birds are just the southernmost elements of the flock that may still frequent the hot springs area of South Hwanghae Province.

The migratory pattern of the white-naped crane is just as puzzling. Are the 38 birds that wintered along the Han River migrants or are they from a sedentary population? And just where do the rest of the 1,000 birds migrate to and from? There was a report of a flock of 312 cranes arriving in Japan's Kagoshima Prefecture on 16 December 1973. Are they some of the birds from the Han River? If so, there is an interval of some 3 weeks (from 21 November) when these birds simply disappear on their way to Kagoshima. Where do they go? Where do they rest? Do they still seek out their traditional wintering areas in central and southern Korea?

The spring migratory pattern is even more puzzling. Assuming that all 312 of the Kagoshima *vipio* migrate into the Han River area in spring to join the 38 birds who spent the winter there, where does the rest of the 1,000-plus flock come from? There are at least 650 birds unaccounted for. Where do they spend the winter? Do they winter elsewhere in the Korean peninsula?

Some brief inquiries on the part of Kr. Kim turned up no clues nor did a trip taken to the area of the Winter Bird Sanctuary at the mouth of the Naktong River in southeastern South Korea. Indeed, cranes were not seen in the sanctuary late in February 1974. Do the 650 white-naped cranes winter somewhere in mainland China? The complete life history of these birds remains a mystery.

FOOD

The red-crowned cranes in Korea in winter feed mainly on rice, insects, fish, pond snails, barley, and sorghum. Two areas in the DMZ were chosen and barley, sorghum, and loaches (a small fish) were put out for the birds. They ate the barley and sorghum but did not touch the loaches, probably because they, unlike captive cranes, were unused to feeding from the buckets into which the loaches had been put. The white-naped cranes fed on rootlets of Graminaceae, fish, and crabs.

PROTECTION OF THE CRANES

By law, no person may kill or capture cranes. The Protection of Game Birds and Hunting Law was revised in March 1967 to provide a fine of 100,000 Won (about \$250 U.S.) or 1 year imprisonment for the shooting or capture of any of the cranes. All 3 species are proclaimed Natural Monuments; red-crowned crane is Natural Monument 202, white-naped crane is Natural Monument 203, and hooded crane is Natural Monument 228. The law is, however, very poorly enforced and outlaws capture the birds to earn a little money. The crane habitats are not protected because there are a lack of data concerning the specific habitat areas and, more important, food production and industry receive 1st priority in land-use planning.

CRANES AND THE KOREAN PEOPLE

As in other Oriental countries, the cranes are highly regarded by the Korean people. The superior beauty, elegance, and purity of the red-crowned crane is transformed into the national costume of the Korean

women--a white coat, black skirt, and long red ribbon worn in the hair. The red ribbon symbolizes the bird's lovely red comb, the white coat is designed from the white wing coverts, and the black skirts are reminiscent of the primaries of the wings. Hakmu, the Korean classical dance, originated from the courtship dance of the cranes. According to Mr. Kim Chon Heung, an expert in this classical dance form, the crane dance first became popular because it was performed following the Royal Ceremony on the last day of the year to chase out diseases caused by devils. This dance was first described in writing in 1493, and is, without doubt, much older. Even today the classical dance teachers visit the zoos to watch the courtship dances of the cranes to learn more about the movements of the birds and their application to the dance form.

The crane is used as a model by students of Oriental painting and is popular with photographers. The crane motif appears in embroidery, clothing, blankets, silk clothes, and holiday cards. At 1 time the embroidered crane was worn on official clothes to signify the wearer's rank. The shyness of the crane is very characteristic of the Korean people--the women are shy and the men very bashful. The Chinese character for the crane, "Hak," is found in thousands of proper names--many Korean men are named Haksun, Hakbae, Duek-Hak, and even a popular wine, Samhak, means "3 cranes."

THE FUTURE OF CRANES IN KOREA

Man's activities pose a constant threat to the cranes. Just this past spring (1974) 1 area in the DMZ was cleared for agriculture which had, since the end of the Korean conflict, been off-limits to all but a few people. The planting of soybeans, although a boon to Korean agribusiness, is another threat to the survival of the cranes and other wildlife in Korea. The DMZ, 24 km wide, separating hostile neighbors, had come to be a sanctuary for wildlife of many species.

Other crane marshes and feeding areas, such as the marshes in Changwon County, South Kyongsang Province, have been drained and cultivated. Yet man's activities can also benefit the cranes. Right now (1974) there is a proposal before the Korean government agency responsible for Natural Monuments, the Bureau of the Cultural Property, to declare the Han River reed island a wildlife sanctuary. Plans are also under way, with the support of the International Crane Foundation, for the purchase of a small adjoining farm to be used as a feeding station for the cranes in the wintertime. This feeding station will be patterned after the successful crane feeding stations already in existence in Japan.

Another threat to the cranes of Korea is the capture of the birds by local people, even though this is forbidden by law. Four red-crowned cranes were known to have been captured in Korea during the first 3 months of 1974. Some of these were birds who had sustained natural injuries but others were injured during capture. Another hazard for the cranes is high-tension wires. The cranes have been known to collide with these wires and die from their injuries as in Japan and elsewhere. During the winter of 1973-1974 an instance of a G. japonensis dying from such a collision was reported and there are probably many similar accidents which are not reported.

The cranes are an important bird in the Korean life-style, and it would be a fitting tribute to the Korean people to have their wonderful cranes once again silhouetting the night sky.

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STATUS AND CONSERVATION OF CRANES WINTERING IN KOREA

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Five species of cranes have been known to migrate to Korea. They are white-naped (*Grus vipio*), red-crowned (*G. japonensis*), hooded (*G. monacha*), common (*G. g. lilfordi*), and demoiselle cranes (*A. virgo*). The white-naped crane is the most abundant of these cranes; 2000 are estimated to migrate annually to Korea. The red-crowned crane is 2nd in abundance. After World War II, apparently less than 50 birds migrated to winter in Korea. In December 1977, however, 120 were confirmed along the Demilitarized Zone (DMZ). It is now known that about 125-150 winter in Korea.

Before the Korean War the hooded crane was as common in Korea as the white-naped crane. Recently, however, the population has greatly decreased; only 1 or 2 are now observed. The exact status of these migrants is unknown, and the population, which had formerly been seen, has not been observed in recent years.

The common crane regularly migrated to Korea before World War II, though the number was small, but since then this species had not been sighted until recently. On 18-19 December 1977, 1 common crane was observed among a flock of red-crowned cranes along the DMZ on Cheolweon Plain in Sabsul-ri, Dongseong-myeon, Cheolweon-gun, Gangweon-do. On 8 February 1979, two common cranes were observed among a flock of *G. japonensis* in the DMZ in Freedom Village, Daeseong-dong, Josan-ri, Gunnae-myeon, Paju-gun, Gyeonggi-do. The demoiselle crane was recorded as a straggler from Ganghwa Island before World War II (Mori 1952), but no recent migration to Korea is known.

MAIN WINTERING GROUNDS OF THE CRANE IN KOREA

Past Distribution

Flocks of *G. japonensis* nesting in the northern part (Heillung-jang) of northeast China and near Khanka Lake in Siberia used to begin their migration toward their wintering grounds in Korea in late October. They would 1st visit Yongcheon area on the downstream of Ab-nog River, Jangyeon, Ongjin, Yeonan, Baechon in Hwanghae-do, and the wetlands at Dangjin, Seosan, and Yesan in Chungcheong-namdo. In severe winters, when water was frozen there, the cranes would move farther down to Songji Lake, Song Lake, and the mudflat on the southern coast of Tongho-ri in Jeollanamdo. Flocks of 10 to 100 wintering cranes were observed there. At that time an estimated 2000-3000 cranes wintered in Korea (Fig. 1).

Some of their habitats were designated as natural monuments under the Japanese regime, e.g., Ongjin Wintering Ground (Natural Monument 17), Seosan Wintering Ground (NM 100), Yesan-sabgyo Wintering Ground (NM 121), and Haenam Wintering Ground (NM 54). However, in the 1950's and the 1960's, cranes ceased to migrate to these places that had been reclaimed or otherwise spoiled. In 1973 the Government deleted these sites from among the natural monuments.

The number of cranes greatly decreased during the Korean War, then slightly increased towards the end of the 1950's, but illegal hunting and indiscriminate captures in the 1960's once again considerably reduced

the number of cranes. Cranes disappeared from their former wintering grounds and scattered in small numbers all over the country. Now there are only a few remaining places in Korea where any large group of *G. vipio* or *G. japonensis* feed or rest. The former now winters at estuaries, and the latter in some grass and paddy fields near the west DMZ and Yangyang on the eastern coast.

Present Distribution

Yeonhi-dong and Gyeongseo-dong in Incheon (Natural Monument 257) are wintering grounds for red-crowned cranes. For 1 month before freezing, from early November to early December, cranes mainly feed on the public mudflats west of Gajeong-dong and Yeonhi-dong in Incheon. However, the range of their feeding activity covers all the public mudflats in Seognam-dong, Weonchang-dong, Gajeong-dong, Yeonhi-dong, Gyeongseo-dong, and Baegseog-dong. They usually feed on earthworms, small crabs, small aquatic invertebrates, and aquatic plant seeds such as *Salsola komarovi* and *Suaeda japonica*. When the tide is low they usually forage along tidal channels so that their bodies are not entirely exposed to view.

After it freezes, when the cranes are unable to find food on frozen mudflats, they usually move to nearby paddy fields in Gyeongseo-dong and Yeonhi-dong to feed on rice. As many as 28 cranes have wintered at Incheon in 1976-1979, but in January 1980 only 3 cranes were seen there. This decline is undoubtedly due to the increasing water and soil pollution in the area.

The wintering ground in the area of Freedom Village at Daeseongdong, DMZ, consists of paddy fields and the DMZ between U.S. Camp Kitty Hawk and Panmunjeom and from Camp Kitty Hawk to Freedom Village at Daeseongdong. Although a small group of 2 to 4 *G. japonensis* and *G. vipio* are sometimes observed between the Bridge of Freedom and Camp Kitty Hawk, most of the wintering cranes are seen on the paddy fields in the valley south of Freedom Village or in the field of reeds in the north DMZ near Daeseong-dong. About 40 *G. japonensis* and 300 *G. vipio* are estimated to migrate annually to the area around Daeseong-dong. They regularly arrive there between early and late November and feed in this area until mid-March.

The wintering ground near Majeong 3-ri, Munsan in Paju-gun, consists of sites on Imjin River, abandoned fields, and paddy fields around the Bridge of Freedom. On 15-19 February 1975, a group of 4 *G. japonensis* was confirmed there, but 1 male of this group was killed by insecticide poisoning. Again on 31 January 1977 more than 10 of the same species were observed, and on 3 February 1977, 23 red-crowned and 62 white-naped cranes were observed. In 1977, 7 red-crowned cranes were observed on 23 February and 5 on 6 March; 57 *G. vipio* were seen on 20 February and 70 on 25 February.

These cranes fed on rice gleanings on the paddy fields south of the Imjin River and roosted on nearby frozen paddy fields. When disturbed by approaching men, they would fly away but would return on the following day. However, no cranes wintered there in the winter of 1978-1979. This group of red-crowned and white-naped cranes seems to have partly been formed

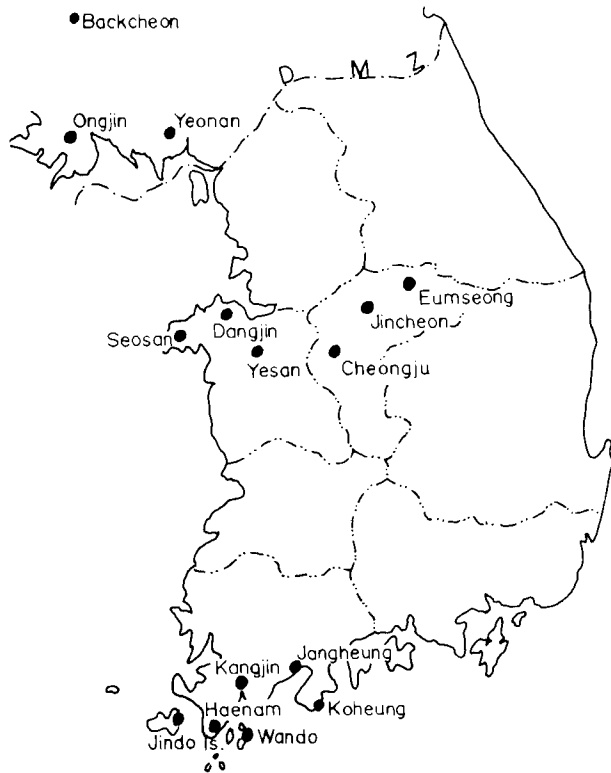


Fig. 1. Wintering grounds of cranes in Korea before World War II.

especially *Salsola komarovi* and *Suaeda japonica* bearing seeds for white-naped cranes (Figs. 5 and 6). *Scirpus maritimus* also grows there, either among the latter 2 species of plants or on its own on the tidal channels. Not only the seed of *S. maritimus* but also its tubers become an excellent food for white-naped cranes because they are abundant in starch.

White-naped cranes begin to arrive at Natural Monument 250 between late October and early November. About 1500-2000 cranes settle there. After freezing, especially after snowfall, they dig out and feed on sedge tubers or seeds fallen on, or buried under, the ground surface. About 500 to 600 cranes would then separate into small flocks of about 20 to 50 cranes and scatter around the DMZ and adjacent districts between Cheolweon in Gangweon-do and Gimpo in Gyeonggi-

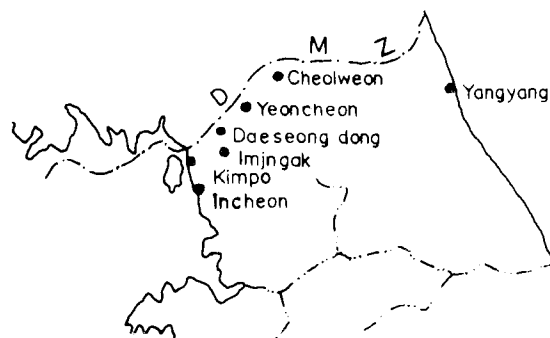


Fig. 2. Wintering grounds of cranes in Korea after the Korean War.

from the groups of cranes that had formerly wintered between Freedom Village and Camp Kitty Hawk. They presumably had flown southward in search of food.

According to Victor M. Franco, a U.S. lance corporal and topographic surveyor whom the author met at Freedom Village in Daeseong 11 December 1977, a flock of about 100 *G. japonensis* wintered on a plain between Cheolweon and Geumhwa from late January to early February 1977. With the help of this information, the author confirmed a flock of 94 *G. japonensis*, including 4 or 5 young birds and 1 common crane, wintering there on 18-19 December 1977. The wintering ground was a vast basin in and south of the DMZ in Cheolweon Plain in Subsul-ri, Dongseong-myeon, Cheolweon-gun, and Gangweon-do.

It seems that they wintered there from late November to mid-March because I could easily observe flocks of 3 to 10 or 30 to 40 cranes scattered around in this area. The roosting area was north of the border, and the feeding ground was the vast basin south of the south demarcation line (Figs. 2 and 3). Thus, the cranes flew south at sunrise and north at sunset, but in severe winters they remained south of the border.

Two adult red-crowned cranes were sighted at the spring in Mechu-gol, Ami 1-ri, Misan-myeon, Yeoncheon-gun, Gyeonggi-do on 2 January 1977. Each year 2 to 3 cranes seem to migrate regularly to this area. On 18 February 1977 a male was captured when poisoned by insecticide near the DMZ in Yeoncheon-gun. On 25 February 1973, 13 cranes were photographed by a newspaperman in Yeoncheon. Several cranes must regularly migrate near the DMZ in Yeoncheon-gun because a flock of about 10 cranes are usually observed in the area.

A female was also poisoned by insecticide on a paddy field near the DMZ in Daeryong-ri, Gyodong-myeon, Ganghwa-gun, Geonni-do on 18 January 1976. Less than 10 cranes seem to migrate to this area for wintering. Occasionally, 2 to 3 *G. vipio* have been seen in this area.

On 8 February 1980, the author unexpectedly observed 2 *G. japonensis* wintering on a 20-ha coastal wetland, 55 km north of Gangneung, at Poweol-ri, Yangyang-gun, and Gangweon-do.

A total of 125-150 cranes is estimated to winter in mid-Korea. These wintering grounds in central Korea are the southernmost range of wintering cranes.

The present wintering grounds in Korea are limited to Yangyang on the east coast, Daeseong-dong in the DMZ, Yeoncheon in Gyeonggi-do, and Yeonhi-dong and Gyeongseo-dong in Incheon (Fig. 4). Those places still existing as wintering grounds of cranes are critically important to their survival. The cranes should be provided with artificial feeding facilities for their use after freezing weather. Then, the general public might be permitted to view the cranes.

The wintering ground of white-naped cranes on the downstream of Han River (Natural Monument 250, designated on 21 February 1975) is a vast delta at the confluence of the Han and Imjin Rivers. East of this area lie Sincheon-ri, Munbal-ri, and Sannam-ri of Gyoha-myeon, Paju-gun, Gyeonggi-do; on the west lie Siam-ri and Hupyeong-ri of Haseong-myeon, Gimpo-gun, Gyeonggi-do. This area contains part of the DMZ and the adjacent districts. The riversides are overgrown with reeds and some *Scirpus maritimus*, but the delta is covered with 4 to 5 species of wetland plants,



Fig. 3. Red-crowned cranes in Cheolweon Plain, Gangweon-do, Korea, February 1978.

do to their final wintering habitat. Another 1000 cranes of the total fly to their final wintering grounds in Kyushu, Japan, by way of the estuary of Nagdong River, Changweon area in Gyeongsang-namdo, and Jeju Island in South Korea.

White-naped cranes, bean geese (*Anser fabalis*), white-fronted geese (*Anser albifrons*), and some 10 species of ducks winter on the estuary of Han River. Swans, vultures, white-tailed eagles (*Haliaeetus albi-*

cilla), and Steller's sea eagles (*H. pelagicus*) are sometimes observed, though their numbers are very small. Thus, the continuous preservation of this delta area is absolutely necessary.

THE STATUS OF CONSERVATION

G. japonensis and *G. vipio* were designated by the South Korean Government as Natural Monuments 202 and 203, and *G. monacha* as Natural Monument 228 on 30



Fig. 4. Red-crowned cranes by their night roost south of the DMZ in Cheolweon Plain, Korea, February 1978.

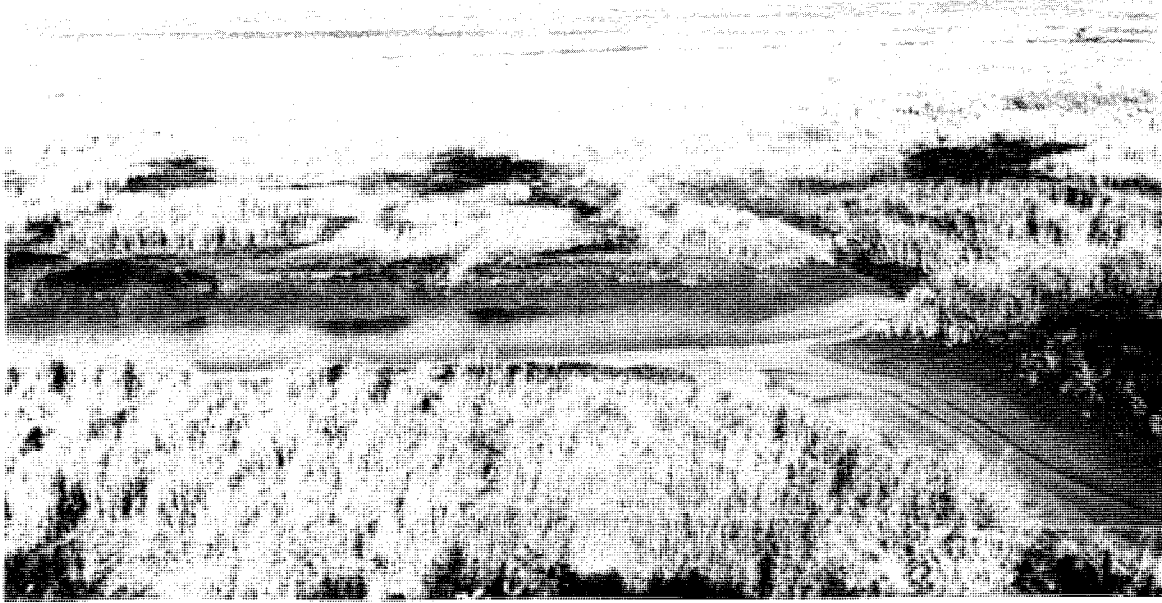


Fig. 5. The wintering ground of *G. vipio* on the Han River estuary, Haseong-myeon, Gimpo-gun, Gyeonggi-do, Korea, October 1978.

October 1970. Since then, these species of cranes have been protected in Korea.

The area of the estuary of Han River in Gyoha-myeon, Paju-gun was designated Natural Monument 250 on 21 February 1975 and was extended to include Haseong-myeon in Gimpo-gun west of the estuary on 22 November 1977. The wintering ground of cranes in Gyeongseodong and Yeonhi-dong, Incheon, was designated and proclaimed as Natural Monument 257 on 22 November 1977.

The Bureau of Culture Property Preservation raised funds, purchased Indian corn and wheat, and began spreading these grains for wintering white-naped cranes at Gyoha-myeon in Paju-gun and at Haseong-myeon in Gimpo-gun on 22 December 1976.

Korea became a member of the International Council

for Bird Preservation in 1960; the Korean National Section office is at the Institute of Ornithology of Kyung Hee University, Seoul. The section began to survey endangered birds listed in *Red Data Book*, other birds faced with the danger of extinction, and rare birds to establish measures for their conservation. The Korean Association for Conservation of Nature also provides many kinds of assistance to protect cranes. The Korean Red Cross in 1977 published and sold over 1 million Christmas seals that depicted rare birds in danger of extinction, spending about 2.5 million won. Korea Yakult Company issued 1 million copies of calendars containing pictures of 12 rare birds and distributed them free of charge to children.

Kyung Hee University Institute of Ornithology in Seoul carries on studies of the present status of cranes, such as 1 entitled "The Ecology of Cranes on



Fig. 6. White-naped cranes wintering on the Han River estuary, 15 March 1980.

their Wintering Grounds in Korea." Indoor research facilities, such as Changgyeongweon Zoological Garden in Seoul, are expected to provide gene banks for artificial propagation of cranes in the near future.

The male crane captured when poisoned by insecticide in Yeoncheon-gun on 18 January 1977 has recovered and was sent to the International Crane Foundation located in Baraboo, Wisconsin, in the hope that he could be used to artificially fertilize a female *G. japonensis* on loan from the Peking Zoo. However, it is doubtful that the male will regain complete health.

Both the Government and civil associations, with the help of all the people, have actively participated in many efforts to protect cranes and preserve their wintering grounds in Korea. I now expect newspapers, radio, and TV stations to join in the efforts for crane conservation.

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CRANES WINTERING IN THE REPUBLIC OF KOREA

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The white-naped (*Grus vipio*) and red-crowned cranes (*Grus japonensis*) are winter residents of the Republic of Korea. One or 2 common cranes (*Grus grus*) occasionally winter with the red-crowned cranes, and the hooded crane (*Grus monacha*) is sometimes observed as it migrates between breeding grounds in the USSR and wintering habitats in southern Japan. The International Crane Foundation has worked with Korean colleagues since 1973 on the conservation of cranes on the divided peninsula. This paper includes an account of the winter biology of *G. vipio* and *G. japonensis* in the Republic of Korea, a description of conservation practices, and an evaluation of the future prognosis for cranes in Korea.

I thank Wildlife Preservation Trust International, New York Zoological Society, and World Wildlife Fund for financing this research in Korea. The Institute of Ornithology at Kyung Hee University, the Museum of Natural History at Ewha Womens University, the Korean Council for Bird Preservation, the Republic of Korea Army, the United States Army, and the United Nations Command are to be thanked for their past and continued support.

THE WHITE-NAPED CRANES

The first flock of *G. vipio* arrive in Republic of Korea in early October and by mid-November their numbers increase to approximately 2000 birds. The majority of the cranes congregate in October and November on salt marshes and associated mudflats of the Han River Estuary (HRE) just south of the Demilitarized Zone (DMZ) where the Imjin River joins the Han River. Between 15 and 20 km northeast of the HRE, several hundred cranes gather along the Sachon River that courses through the center of the DMZ in the vicinity of Panmunjom, and a small flock of 15 to 20 cranes winters in the Cholewon Basin of the central highlands, approximately 75 km east of the HRE (Fig. 1). The Panmunjom and Cholewon populations are stable through winter, whereas approximately one-half of the HRE flock migrates south in late November and is presumed to be the group that winters near Izumi in Kyushu, Japan (Nishida 1969). Flock size and arrival dates in Japan correspond to numbers and chronology of departures of cranes from Korea (Walkinshaw 1973).

G. vipio feed in brackish water marshlands and rice paddies. They are predominantly vegetarian in winter and in the salt marshes of the HRE they feed principally on tubers of the sedge (*Scripus maritimus*) and on seeds of several grasses. In rice paddies they mainly feed on gleanings.

The HRE is 2-3 km wide and is long and shallow, features that combine to produce the world's 2nd highest tides. At high tide the basin is filled with water and the only indication of land is emergent vegetation of salt marshes along the east and west banks. At low tide, mudflats are exposed over most of the estuary. Winding channels lead through mudflats and thus to the Han River's freshwater flow. *S. maritimus* is the predominant plant in the salt marshes. In winter its leaves are dead and the plant survives as bean-sized tubers in the mud.

The majority of cranes roost together in a large flock on the salt marshes and mudflats during the

night. During the day 2 social units evident are flocks that usually contain a predominance of non-breeding birds, and family groups including a pair and their 1 or 2 chicks. The families are usually the 1st to fly from the roosting flock at dawn. Some families and pairs establish feeding territories roughly measuring a diameter of from 10 to 20 m from their prime feeding spots. The territories are rigorously defended by threat postures and unison calls (a synchronized duet between the male and female of a mated pair). The rest of the cranes usually feed at or near the roosting site and they do not evidence territorial behavior. Usually this major flock is surrounded by family groups, some of which defend territories. Often small flocks leave the main flock and depart to other areas of the HRE; however, they usually return at dusk to roost with the large flock.

G. vipio prefers to feed in the recently wetted area of the marsh, usually along tide channels where they can easily dig for tubers in the moist mud. In the interior of the marshes where the soil is sometimes not covered by water at high tide, cranes walk slowly with head down searching for seeds and perhaps for small animals. In contrast, while digging for tubers the cranes move from their digging area and each day expand their excavated area through the sedge beds. After the main flock has fed in an area of the HRE for several weeks, the dead emergent vegetation is usually trampled and buried by the excavating. The entire area eventually resembles a cultivated field. In 1973 and 1974 the cranes predominantly fed on the marshes of the southeast part of the HRE, whereas in recent years they have concentrated on the northeast area. Flock movement undoubtedly allows the "recovery" of the sedge.

The cranes usually feed in company with thousands of bean (*Anser fabalis*) and white-fronted geese (*Anser albifrons*) and mallards (*Anas platyrhynchos*). The white-tailed sea eagle (*Haliaeetus albicilla*) and the golden eagle (*Aquila chrysaetos*) feed on the geese and ducks and each time 1 of the raptors flies over all the anatids fly but the cranes pay little attention to the large predators.

The HRE appears to be a major staging area for *G. vipio* in the eastern portion of their range, just as the Jasper Pulaski Wildlife Area in northcentral Indiana is the autumn staging area for the majority of eastern greater sandhill cranes (*Grus canadensis tabida*) in advance of their departure to wintering grounds. Like the sandhill cranes, staging of white-naped cranes is more pronounced in autumn than in spring.

When the cold winds make the Sachon River a less preferred roosting site, the cranes wintering near Panmunjom roost on open water and sandbars of a sheltered lake near Panmunjom. If snow covers the rice paddies, the majority of these cranes flies south to feed at either the HRE or the salt marshes near the mouth of the Imjin and Sachon Rivers. However, if the rice paddies are without ice, the cranes prefer to remain in the Panmunjom Valley and feed on gleanings. Unlike the HRE crane families that evidence territorial behavior, the Panmunjom crane families are usually social in small or large flocks wandering around the rice paddies, investigating, probing, and then walking

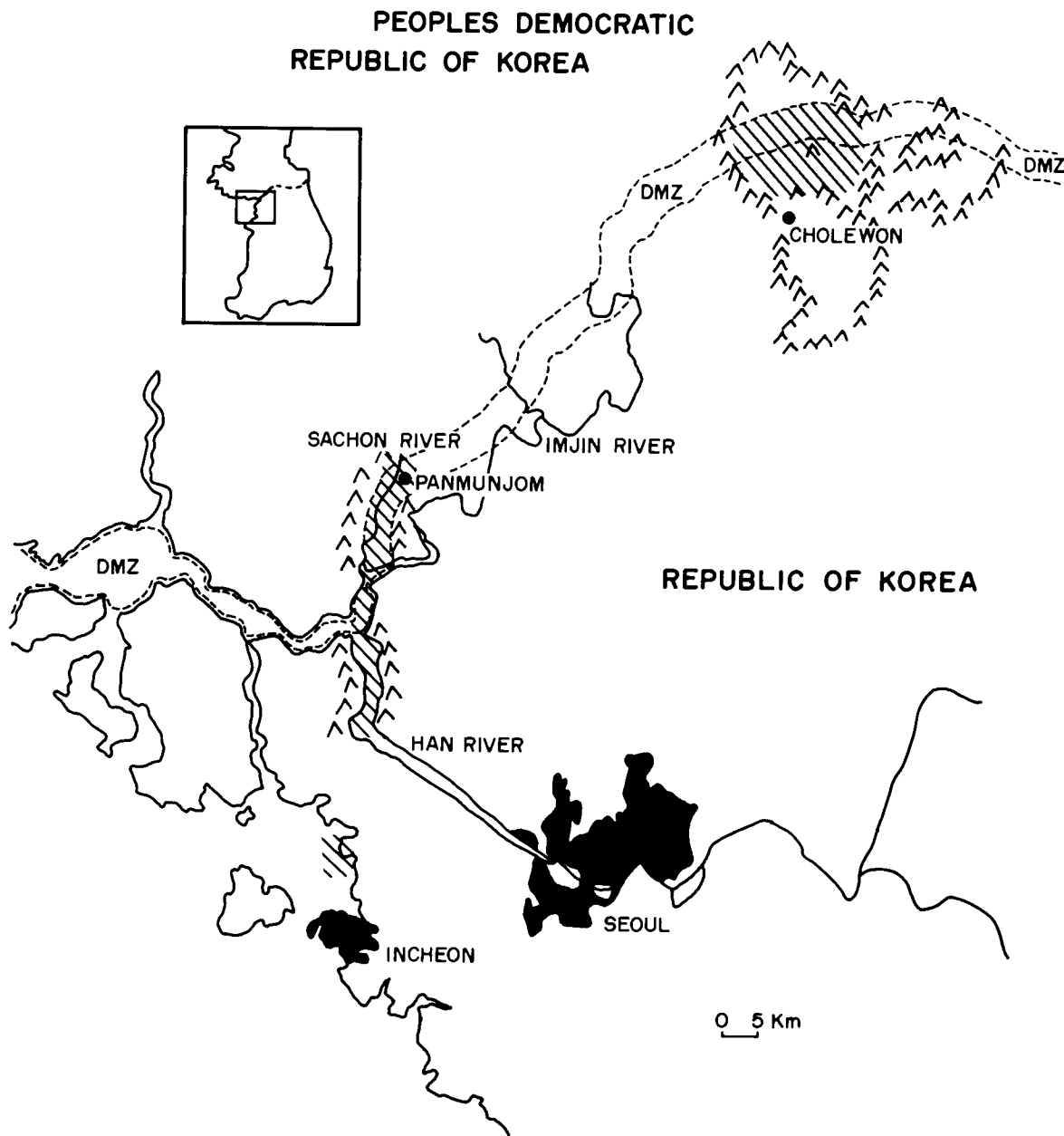


Fig. 1. Distribution of cranes wintering (shading) in the Republic of Korea.

on to another spot. When feeding on tubers, *G. vipio* is a digger, seldom walking about, and often exhibits territorial behavior, but while feeding on seeds he is a wandering searcher and usually nonterritorial in behavior.

The small flock of *G. vipio* wintering in the Cholewon Basin consisted of only 6 birds when the group was discovered in the 1977-1978 winter but had increased to 15 birds in the winter of 1980-1981. They feed in rice paddies on gleanings with a large flock of *G. japonensis* and also roost with the red-crowned cranes.

There may be other small flocks of *G. vipio* wintering in other agricultural regions of the Republic of Korea; however, they have not been located. Research

has been concentrated in the DMZ and nearby environs because we were mainly interested in *G. japonensis* and Japanese crested ibis (*Nipponia nippon*), which are known to survive only in and near the DMZ.

Each winter the *G. vipio* flocks contain many pairs with 1 or 2 chicks. Approximately 15% of the flock is birds-of-the-year, productivity that indicates stability of breeding habitats and population increase.

THE RED-CROWNED CRANES

There are 3 populations of these magnificent cranes wintering in Republic of Korea. A group of about 15 (1980-1981 census) winters on the mudflats and rice paddies just north of the west coastal city of In-

cheon. A 2nd group of about 40 winters in Panmunjom Valley along the Sachon River, while a 3rd flock of 80-100 winters in the Cholewon Basin. They arrive from mid-November through early December, somewhat later than the *G. vipio*, and they remain in Korea well into March. These groups constitute the most southerly wintering *G. japonensis* on the Korean peninsula, although in former times the species was reported as far south as the Naktong River delta in the extreme southwest (see Kyu and Oesting, this Proceedings). The mainland populations of *G. japonensis* are distinct from the group of about 270 birds in southeastern Hokkaido, Japan. The female's voice in the unison call is longer and of lower frequency on the mainland than in Japan, and the mainland birds are migratory, whereas those in Hokkaido are sedentary.

Whereas *G. vipio* is predominantly a vegetarian, *G. japonensis* is more carnivorous, though they also feed on rice gleanings. The birds near Incheon spend part of the day scattered in family groups, pairs, and singles over the mudflats at low tide, feeding on aquatic animals in the tide pools and channels. At high tide they are forced to the upper tidal marshes and are sometimes observed in a single flock, slowly walking along the mudflats searching for annelids. They often fly into the rice paddies to glean and to drink from freshwater streams that run between the agricultural fields. Each winter since 1977, 1 family group including a single chick was present in this flock. This family group usually fed on the tidal flats and was occasionally territorial to other cranes. *G. vipio* were never observed with the *G. japonensis* near Incheon, although the HRE is only 30 km northeast over a narrow range of mountains on the Kimpo Peninsula.

The Panmunjom group of *G. japonensis* when first discovered in the Republic of Korea in 1974 numbered approximately 36 birds, of which 10 were chicks. However, counts from 1977 through 1981 indicate about 40 birds with 1 to 3 chicks each winter. In early winter they feed predominantly on rice gleanings and, as weather becomes colder in late December, they roost more in areas around the Sachon River and at springs throughout the valley that seldom freeze. There they probe for aquatic animals, particularly amphipods, snails, and small eels.

The cranes roost together in 1 or 2 flocks along the river, in sheltered, remote rice paddies, in small valleys, and on the ice of a small lake. In mild weather they leave the roost at dawn and disperse to feeding areas. Pairs and family groups tend to be territorial during mild weather and drive other *G. japonensis* from the wetland in which they are feeding, although they are more tolerant of *G. vipio*. Usually when the mild weather is interrupted by a cold front, the cranes abandon their feeding territories, flock together, and circle high in the sky as if to migrate further south. They return to their roosting areas and remain flocked during the severely cold weather. They may remain on their roost until early afternoon during this cold weather, flying out to wetland feeding areas for several hours, then back to the roosts.

G. japonensis at the International Crane Foundation put on thick layers of body fat in autumn, and a large male may weigh as much as 11.3 kg (25 pounds) in November. During winter this fat is metabolized and by spring the bird may weigh 12 to 20% less than it did in autumn. Apparently, this also happens in the wild. The Panmunjom birds feed on the abundance of rice in the paddies in late autumn, then become comparatively inactive during the coldest winter days, presumably surviving on their fat reserves.

As the weather becomes mild again in late winter the cranes leave the roost early in the morning. Instead of flying to the rice paddies they visit freshwater wetlands and before migration in mid-March seem to feed almost exclusively on aquatic animal food.

The nonbreeders at Panmunjom are nomadic in their feeding behavior, whereas most of the pairs and families usually feed in the same region through much of the winter. The nonbreeding flock feeds in 1 area for several days, then, for no apparent reason, moves to another region.

The Cholewon flock contains the majority of the *G. japonensis* wintering in Republic of Korea. Since their discovery in 1978, only 1 to 3 chicks have been observed in the flock that numbers between 80 and 100 cranes. The 4-km-wide DMZ that transverse the Cholewon Basin contains woodland, grassland, and riparian habitats, the latter of which are occasionally used as feeding and roosting regions for *G. japonensis*. However, their preferred habitat lies in the expanse of rice paddies and small freshwater streams that cover the valley floor for 8 km south of the DMZ, and which, for security reasons, is vacated by civilians throughout winter. Consequently, the cranes have approximately 100 km² of excellent habitat free from disturbance.

The cranes roost in several flocks on the rice paddies and along the rivers and streams at night--then feed in the same areas throughout the day. Territorial behavior has not been observed, although the few pairs that have chicks tend to separate themselves from the flocks during the day.

INTERACTIONS OF RED-CROWNED AND WHITE-NAPED CRANES

Mixed flocks of *G. vipio* and *G. japonensis* were found at Panmunjom and Cholewon, with a predominance of *G. vipio* at the former and of *G. japonensis* at the latter. At Panmunjom the *G. vipio* usually roosted in a flock adjacent to a roosting group of *G. japonensis*, and the *G. vipio* usually left the roost before the *G. japonensis* each morning. Flying cranes had a stronger tendency to land where cranes were on the ground than to land in an area where there were no cranes. *G. vipio* often landed with *G. japonensis* and vice versa. The 2 species were often seen feeding together on gleanings in the rice paddies, with the *G. japonensis* usually dominant over the slightly smaller *G. vipio*. However, when an artificial feeding station of corn was established near Panmunjom, a pair of *G. vipio* threatened, attacked, and supplanted several *G. japonensis* that tried to feed. As more *G. japonensis* arrived, the *G. vipio* discontinued their efforts to displace all other cranes of both species. Conversely, the territorial *G. japonensis* pairs and families drove all other conspecifics from their feeding area but they did not attack *G. vipio*, although they were dominant over the latter.

CONSERVATION PROGRAMS

The salt marshes of both the east and the west side of the HRE, including the majority of the staging and winter habitats of *G. vipio* and mudflats north of the Incheon, which are winter habitat to a small flock of *G. japonensis*, have been protected by the Republic of Korea Government as Natural Monuments. Artificial winter feeding programs for both crane species were undertaken at Panmunjom from 1974 through 1978, at Incheon in 1977, and at Cholewon from 1978 to 1980, but were discontinued for logistical reasons and be-

cause there was an abundance of food from the rice gleanings (Archibald 1978). The no-man's-land nature of the DMZ, which stretches across the country at the 38th parallel, assures the privacy of the cranes. At Panmunjom the cranes are found entirely within the DMZ; and at the HRE and Cholewon they frequent the heavily guarded buffer zones just south of the DMZ.

In recent years the Korean Government has assumed an active role in nature conservation, and the preservation of rare birds has been well advertised by the mass media. If the G. vipio continue to increase, they can be expected to start wintering in cultivated fields distant from the DMZ. Public education programs concerning crane conservation brighten the future for cranes in Republic of Korea. Both G. vipio and G. japonensis can survive through winter in agricultural areas if protection of the birds is provided.

Each winter the same number of G. japonensis return to Korea with few chicks in the blocks. Whereas the population in Hokkaido usually contains from 12 to 14% young-of-the-year (Freeman 1981), only 1-3% in the flocks wintering in the Republic of Korea are young birds, an indication of a serious problem on the breeding groups of these cranes in China and the Soviet Union. Since the 3 winter flocks of G. japonensis in the Republic of Korea remain about the same size from winter to winter, the presence of birds in adult plumage and in pairs makes it unlikely that these cranes represent a predominantly nonbreeding flock of subadult cranes. Nor do these flocks simply border on the south of the majority of breeding pairs in the People's Democratic Republic of Korea.

In Japan, a pair of G. japonensis requires 3 to 7 km² of shallow wetland habitat as a breeding territory, defended turf on which they nest and rear their young. The cranes will not nest if they are disturbed or their wetlands are burned or drained. Perhaps habitat alterations of the wetlands in northeastern China and southeastern USSR are responsible for the poor productivity of the mainland G. japonensis in recent years, an assertion that has been confirmed by the members of the Soviet Working Group on Cranes.

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STATUS AND DISTRIBUTION OF CRANES IN IRAN AND SOME OBSERVATIONS IN IRAQ

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Very little detailed information about Iranian wetlands existed at the beginning of this century and that available was unfortunately rather vague. The recent literature about birds in Iran largely follows Zarudny (1911) and other workers who collected in Iran in the late 19th and early 20th centuries. These early workers seldom listed any quantitative data concerning the abundance of species; consequently, it is now virtually impossible to come up with any firm conclusions about population trends during the present century. The following notes are based almost entirely on wetland surveys and waterfowl studies conducted by the Ornithology Unit, Iran Department of Parks and Wildlife, throughout Iran from 1966 to 1975, and in Iraq from 10 January to 3 February 1979. In the latter trip I was accompanied by E. Carp and I wish to acknowledge his assistance.

The work of the Ornithology Unit included winter, spring, autumn, and breeding season surveys at all major wetlands. Special attention was given to the midwinter (January) waterfowl counts and in the winters 1971-1972 to 1974-1975 all wetlands of any significance for wintering waterfowl were censused. Aerial censuses were conducted at the large wetlands of Khuzestan, Fars, and Seistan. Three species of cranes were recorded: the common (*Grus grus*), Siberian white (*G. leucogeranus*), and demoiselle (*Anthropoides virgo*).

COMMON CRANE

The common crane is a common winter visitor to arable land and wetlands in the south (Fig. 1) along the Karkheh, Dez, and Karun Rivers in Khuzestan, in central Fars, and in Seistan. Smaller wintering flocks were also reported from Ilam area, Izeb Lakes in Khuzestan, Halileh Rud Marshes near Bushire, delta of Monde River (Gulf Coast), along the Zaindeh Rud near Isfahan, and near Tayebad in northeast Khorasan (only in mild winters). This crane arrives in late September and early October and departs in March and early April. It is a regular migrant in spring and autumn in the southeast Caspian region (particularly the Gorgan Bay area), and in the valley of Jowin Rud near Sabzevar, Khorasan. The common crane is occasionally seen in small numbers during migration on areas of arable land or at small wetlands in the west-central plateau (e.g., Tehran area, Esfahan area).

Three recent records of summering nonbreeders are 1 seen Pol-e Dokhtar Marsh, Luristan, 3rd week of May 1972; 1 seen at a small lake on Turkoman Steppes, Gorgan, 2nd week of July 1972; and 1 seen at Akh Gol Lake, northwest of Azarbaijan, 2nd week of July 1974. There are no recent records of nesting in Iran.

Midwinter counts of common cranes in Iran are listed in Table 1. Allowing for incomplete coverage,

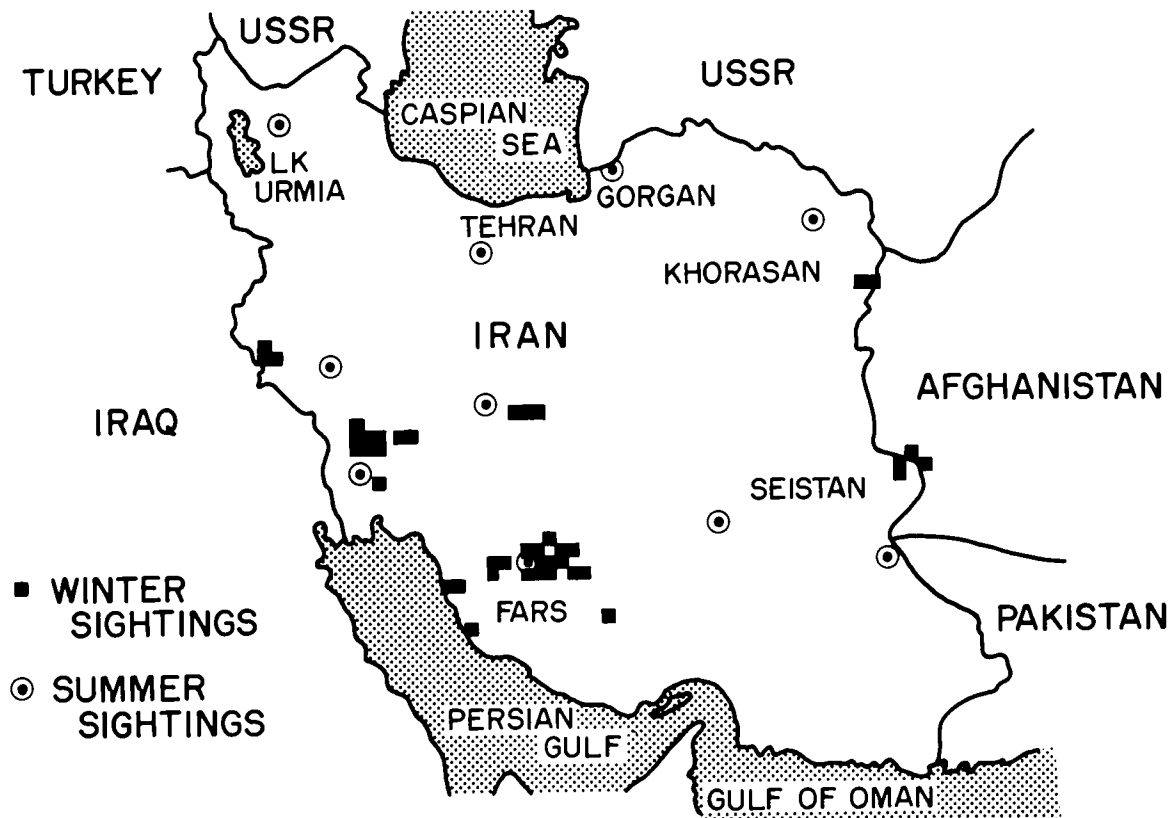


Fig. 1. Distribution of common cranes in Iran, showing winter sightings and summer observations of nonbreeders.

total estimates for the wintering population of these cranes are as follows: 1971-72, 2,500-3,000; 1972-73, 2,000-2,500; 1973-74, 2,000-2,400; and 1974-75, 2,500-3,000.

Common cranes observed during our brief visit to Iraq are listed in Table 2. According to local farmers and shepherds, large numbers of common cranes occur on the plains around Haur Ash-Shuwaija, near Kut (32°42'N, 46°00'E), on the Attariya plains east of Baghdad, and on the plains east and northeast of Baghdad toward the Iranian border. Obviously, during the present survey we observed only a tiny fraction of the common cranes wintering in Iraq.

SIBERIAN WHITE CRANE

The Siberian white crane formerly occurred in winter in the South Caspian region, Turkoman Steppes, and, according to Zarudny (1911), in Seistan. Caspian records are summarized by Schuz (1959). The last record in the south Caspian region was at Lenkoran, USSR, in 1925. In February 1978 a flock of about 11 Siberian cranes was discovered wintering near the town of Feredunkenar on the east Caspian lowlands of north-east Iran. The cranes wintered in the midst of a duck trapping complex and had gone unnoticed by ornithologists because of the improbability of finding them wintering in such proximity to man, and because of the waterfowl harvesters' reluctance to allow anyone but themselves to approach the trapping area in fear of frightening the ducks away from the traps. The cranes

have wintered in the locale for as long as the local people could remember. Birds seen in migration at the Astrahan Nature Reserve in the delta of the Volga River in the Soviet sector of the Caspian Sea may be the only group still wintering in Iran.

DEMOISELLE CRANE

The demoiselle crane is a migrant in the south Caspian region and a winter visitor in Seistan, along the Gulf Coast, and in southern Persian Baluchistan (Zarudny 1911). It is a winter visitor to southwest Iran (Hue and Etchecopar 1970). However, there are very few reliable records and the only recent records are 1 seen at Lake Maharlu, Fars, 1965-1966 (L. Cornwallis, pers. comm.); 1 seen 17 August 1972 at Lake Kobi, Azarbaijan; 2 collected November 1972 near Chalus, Mazandaran; and 2 seen 15 September 1973 at Miankaleh Peninsula, Mazandaran. Obviously the species is now only a very uncommon migrant through Iran.

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Table 1. Midwinter censuses of common cranes in Iran, January 1972-1975.

Province	Locality	Winter			
		1971-72	1972-73	1973-74	1974-75
Khorasan	Tayebad area	22	46	-- ^a	274
Isfahan	Zaindeh Rud	--	30	13	51
Ilam	Ilam area	206	250	--	--
Khuzestan	Karun, Dez, and Karkheh	1,315	387	711	299
	Plains south of Ahwaz	0	0	0	4
	Izeh Lakes	--	--	--	400
Gulf Coast	Halileh Rud delta	--	--	120	69
	Monde River delta	--	--	--	27
Fars	Dasht-e Arjan ^b	32	19	75	2
	Lake Parishan ^b	3	182	275	275
	Lake Maharlu	0	0	7	0
	Dasht-e Baiza	0	0	14	7
	Kur Valley	0	5	0	61
	Bakhtegan and Tashk ^b	9	548	375	541
	Darab/Lar	500	0	--	0
Seistan	Hamoun-i Puzak South	15	145	8	450
	Hamoun-i Sabari ^b	0	17	6	0

^aNo census taken wherever -- is present.

^bLocalities within the Department of the Environment's reserves.

Table 2. Observations of common cranes 10 January to 3 February 1979 survey in Iraq.

Date	Locality and coordinates	Cranes	Crane activity
14 Jan	15-ha steppe pond and cultivated plains 17 km W Qalat Salih, 31°30'N, 47°14'E	12	In flight
18 Jan	Center of Haur As Sa'adiyah from E shore 32°09'N, 46°38'E	62	Roosting
19 Jan	10-ha steppe pond and cultivated plains 43 km N Amara, 32°06'N, 46°50'E	32	In flight
26 Jan	Steppe plains near marshes 12 km NE Fuhud, NW Haur Al Hammar, 31°01'N, 46°43'E	4	Family feeding (2 ad, 2 juv)
29 Jan	15-ha desert pond 30 km SE of Nasiriya, 30°52'N, 46°22'E	6	Feeding
1 Feb	Lake Razazah, seen from W shore 5 km S of N end, 32°59'N, 43°33'E	5	In flight
2 Feb	Desert plains, arable land, and small marshes at Attariya, 45 km E of Baghdad, 33°15'N, 44°55'E	5	Feeding

Red-Crowned Crane



Photo by Yu Shibnev.

NESTING OF THE RED-CROWNED CRANE IN THE CENTRAL AMUR REGION¹

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The red-crowned (*Grus japonensis*), a rare and endangered species, is listed in the red book of the International Union for the Conservation of Nature. The 1st data on this species in USSR were gathered by Przheval'sky from 1867 to 1869, and the 1st nest was found by the Dorries brothers in 1888 (Dorries 1888). The 1st reference to this crane in Amur Province was by Stegman (1930), who, having discovered a specimen in 1928 at the regional museum in Blagoveshchensk, supposed that it came from the central Amur region. In 1956 and 1957 this species was found on its nesting grounds in marshy areas of the Amur floodplain near the villages of Ukrainok, Severnoye, and Skobel'tsino.

During more than a century of research (up to 1972) on the red-crowned crane in USSR, only 7 nests have been found. Until recently the incubation period was unknown (established only for cranes living on the island of Hokkaido [Taka-Tsukasa 1967]) and the downy chick has not been described in detail. There was practically no information on the nesting and behavior of the birds in the territories of the USSR, on the size of the territory defended by a pair, nor about the nesting density. There have been no clear ideas about the voice of the species and the functional meaning of the cranes' auditory reactions, nor about the existence of any differences between island and mainland populations of cranes. Finally, there has been no organized information about the factors limiting population size in this species, information that is essential for the development of protective measures.

During the summers of 1974-1976 (17 June-20 August; 20 April-20 September; 22 April-22 June) I conducted field studies in southern Arkharinsk District in Amur Province. Studies made while traveling through the region were alternated with regular observations of 2 pairs from blinds, made for 272 hours in 1975 (26 April-25 May), and observations of 1 of these pairs in 1976 (3-27 May). According to data from local correspondents, the 1st red-crowned cranes in 1976 were seen 24 March (5 feeding in a marsh on the western shore of Lake Kurgloye, 5 km from Ukrainok Village).

POPULATIONS, NESTS, EGGS, AND CHICKS

In 1975, in the marshes of the Bureinsk-Arkharinsk lowlands, 8 pairs of red-crowned cranes nested in an area of 162 km² along with 8-12 birds which were apparently nonbreeders. In 1976 the numbers of birds arriving in the spring were approximately the same, but due to extensive burning of the grassy vegetation only 1 pair nested. About 5 pairs were noted during these years in the area between the Arkhara and Khin-gan Rivers.

During the latter part of April the cranes occupied nesting territories among tussocky cotton-sedge marshes and flooded tussocky meadows, mixed with oak-birch islands (in dry patches) consisting of 2 species of birch, mongolian oak, aspen, and willows, with a sparse undergrowth of willow, hazelnut, and other shrubs, and oak and aspen saplings. The size of a territory defended by a pair of cranes, determined by

observing the territorial activity of the birds, was (for 3 pairs) 4.02-12.3 km². Four nests were situated on extensive marshes (0.8-1.2 x 1.0-2.0 km) surrounded by scattered patches of woods, and 1 was located on a marsh 0.2 km wide by 0.5 km long. The distance from the nests to the edge of the wooded patches was 90-300 m, between neighboring nests was 2.7-4.0 km, and the distance to the nearest settlement was 8-10 km. One pair observed during 2 seasons in 1976, built their nest 600 m away from the 1975 nest.

The birds chose nest sites of flooded, old sedge marsh which had not been burned the previous autumn (60-80 cm tall in 1975, 30-40 cm in 1976). In the area between the Bureya and Arkhara Rivers all marshes are passable throughout the year. The period of highest water levels occurred in May-June and towards the end of August through September almost all the marshes dried out, with marshy areas remaining only near the shores of the region's numerous lakes.

The 5 nests consisted of oval platforms measuring 74-100 X 90-120 cm situated on several tussocks or level turf and raised above the water 15-30 cm. The thickness of the nests, which consisted of entire plants or leaves of sedge and bluejoint grass gathered nearby, varied from 5-20 cm. A very shallow gutter (2-4 cm) was pressed down 1-2 cm under each egg and was sometimes covered with a softer material such as the leaves of bluejoint grass.

I studied the incubation periods of 5 nests, and looked at the duration of brooding in 2 of these. The 1st eggs in 1975 (4 pairs) were laid on approximately 16, 18, and 22 April and 7 May; in 1976 (1 pair) the eggs were laid on 22 April. Females laid the 2nd egg 2-4 days after the 1st. Full clutches consisted of 1 egg (1 nest) and more often of 2 eggs (4 nests) having an oval or, less often, an elongated oval shape (Makatsch 1974). The shell was basically creamy white, covered here and there with pale ochre and (smaller) reddish-brown spots, forming a faint wreath or cap at the blunt end of the egg. The eggs were parallel to each other in the nest and were 2-6 cm apart. The size of 8 eggs from 5 clutches is given below in millimeters:

1975	99.4 × 67.4 and 95.3 × 67.5 ² ; 103.6 × 68.5 and 102.4 × 70.5; 99.7 × 65.6; 111.8 × 67.4 (1 of 2 eggs in clutch)
1976	102.6 × 68.2 and 98.5 × 69.6 ²
Ave.	101.66 × 68.09

The average size of 17 eggs from red-crowned crane nests on the island of Hokkaido (Walkinshaw 1973) was 101.17 × 64.88 mm--4.75 mm narrower than those (16) known to us from the mainland (a clutch in the collection of ZIN AN [Acad. Sci.] USSR by Shchul'pin; my own data). Clutches with great variability in color are characteristic of cranes that nest on islands. Walkinshaw (1973) describes eggs with and without spots, with milky white, brownishgray, pale winecolored or light brown shells, whereas for mainland birds only spotted, creamy white eggs are known.

¹Translated by W. E. Ervin. Originally published in Bull. Moscow Soc. Res. Nature 82:39-53.

²Clutches of the same pair.

During both seasons most eggs (71%) appeared in the nest before 26 April, the latest date being 10 May. Periodic frosts were observed on the soil surface as late as 18 May in 1975 and 16 May in 1976. Birds began incubating as soon as the 1st egg was laid. Both birds incubated the eggs in all 5 nests. For 2 pairs observed in 1975 (and for 1 of these in 1976) it was noted that 4 nesting shifts occurred during daylight hours and at night only the female remained on the nest. If she were chased from the nest at dawn, then the male would relieve her after 20-25 minutes and the birds would complete 6 shifts during the day, so that at night the female again ended up on the nest.

At 1 nest, for example, the male relieved the female on 10, 18, and 21 May from 0501 to 0553 and 1201 to 1206, and the female relieved her mate from 0746 to 1047 and 1337 to 1710. During 7 days of observation (between 26 April and 22 May) the female sat on eggs for 119 hours and the male 49 hours. Near the end of incubation there was a decline in the amount of time the male spent incubating the eggs. During the day the female spent from 1 hour and 19 minutes to 7 hours and 23 minutes at the nest without being relieved, and the male spent from 1 hour and 34 minutes to 5 hours and 28 minutes, although the average ratio was 3.47:3.45 (female:male).

The incubation period for the 1st egg of 1 pair was 29 days and was not less than 31 days for the other egg. Chicks hatched in 4 nests on 17-18, 18-21, 23-26 May and 8-10 June in 1975 and 22-25 May in 1976. The 1st crane chick arrived 2-4 days earlier than the 2nd and in 1 instance was 5-20 m away from the nest at the moment the 2nd chick hatched (in 2 other situations the 1st chick was being brooded when the 2nd hatched). The 2nd chick, having barely dried out, would abandon the nest and spend its 1st days several meters away from the nest. During this time both chicks often sat side by side, no farther than 1 m apart.

After the appearance of the 2nd chick we usually found the egg shell 1-3 m from the nest in the water, with a piece of the shell sometimes remaining in the nest. Once the female threw a nearly intact shell over the edge of the nest immediately after the chick hatched.

During the 1st and 2nd days of life measurements of the downy red-crowned crane chicks (3 from 3 nests) were as follows: tarsometatarsus--42, 46, and 46 mm; "wrist" (i.e., brachium to antibrachium)--29, 28, 32 mm; bill (to feathered forehead)--28, 25.9, and 25 mm; bill (to the anterior edge of nares)--13.3, 14.2, and 13.4 mm. The egg tooth was white. The bill was orange-yellow from base to nares, beyond which it was whitish (1 of the chicks showed a faint darkening in the middle of the whitish area). The iris was dark brown. The legs were light flesh color with a light horny layer on the central part of the tarsometatarsus and shank, and the toes were lighter in color and almost without the horny covering. The claws were the color of the toes, with light tips. The buccal cavity was light pinkish-white or yellowish-pink.

The chick was covered with thick yellowish-brown down, shortest on the head (3-6 mm) and longest on the back and belly (10-15 mm). A dark design was noted on the back, and the lower part of the body was light in color. The sides of the head, the front part of the neck, and the breast, belly, and flanks were light in color, with a rusty-ochre tinge. The darkest areas on the back also projected downwards toward the base of the thighs. Behind each shoulder was a light-colored,

sharply delineated spot, and the lightest down was at the forward edge of the base of the wing and under the wings.

At the approach of a person the downy young would sit hiding near a tussock or sometimes in the water, or would attempt to walk away while holding their little wings out horizontally, even though only a few hours earlier they had barely been moving. The plumage of the belly almost never became wet. The voice of the chicks consisted of a high, melodic squeak--"peerr, peerr" . . . or "pee-ee, pee-ee . . ."

Two 3- to 5-day-old chicks from 2 nests had the following dimensions (in mm): shank, 47 and 52; bill (to feathered forehead), 27.5 and 26; bill (to the anterior edge of nares), 14.2 and 14.8. Compared to the 1- to 2-day-old chicks their down was lighter, but the distribution of light and dark areas remained the same. The legs were slightly darker. The voice was a light, silvery trill surprisingly reminiscent of the ashy minivet (*Pericrocotus divaricatus*). The chicks stood firmly on straight legs and walked about with certainty. When we sat down next to the 1-day-old and 3-day-old chicks of 1 pair of adults and put a finger near the bill of the elder chick, it began to peck at it awkwardly, and later attacked the younger chick.

BEHAVIOR, INCUBATION, AND HATCHING OF YOUNG

An incubating crane would periodically raise its head rather quickly above the sedge and look about. Then slowly, as if falling asleep (which apparently did occur at times), the crane tucked its bill into its neck while tilting its head, and lowered its head back down into the sedge. A frightened bird would raise its head sharply above the grass and just as quickly lower the head. An incubating female behaved in this manner when she noticed a strange crane feeding far from the nest 1 evening. This indicates that partners can probably recognize each other from a distance of 500-600 m.

An incubating bird sometimes cleaned its plumage and drank water without getting up from the nest. From time to time it would stand up slowly and smoothly, look around, turn the eggs and, often after having looked around 1 more time, would sit back down on the nest. More often, a crane which had stood up from the nest would clean itself, flap its wings several times, shake itself with a deafening sound (audible for 500-600 m), stretch, and peck at something nearby. While turning the eggs a bird sometimes shook its tail, which had been lowered slightly below its usual position so that it was adjacent to the long secondaries.

On the average the cranes stood up at the nest after 39-55 minutes for 2-3 minutes--after noon 2-3 times less often. The birds did not stand at the nest before the day's exchange of incubating duties with their mates. The maximum intervals between turning the eggs occurred in the early morning hours and the minimum intervals occurred at midday and in the afternoon. The frequency with which each partner stood at the nest was approximately the same (e.g., on 10 May the female changed the position of the eggs 13 times, the male 12 times--and on 18 May, 11 and 10 times, respectively, during daylight hours). The frequency of standing did not change during a light drizzling rain, and did not depend on the duration of incubation, increasing slightly only immediately before hatching. The birds probably did not stand up at the nest during the night. The position of the incubating bird changed after turning the eggs. Only once during

the entire time of observation did an incubating crane sleep, having placed its head on the raised plumage of its back, and it only looked around twice during 105 minutes.

When it was time for 1 bird to relieve the other at the nest, it would approach flying or walking from its feeding grounds and sit or pause 20-50 m from the nest, and then would walk stealthily, squatting slightly so that only the neck and black secondaries would appear above the sedge. When 1.5-2 m from the nest it would straighten to its full height and stop. The incubating partner would leave the nest (sometimes 1st changing the position of the eggs) and both birds would stand nearby for some time. Then the bird beginning the new shift would turn the eggs and the partner would move a few steps away, stop, crouch slightly, stretch its neck forward for a moment parallel to the ground, jump up (or sometimes run) and fly away, heading towards the feeding grounds. When the bird had flown away to a distance equal to half its journey, or had landed, the crane remaining on the nest would look around and settle on the clutch. Birds approaching to change shifts, or leaving after changing, flew 3-5 m above the ground.

More than 50% of the time the bird beginning the new shift began to preen itself near the nest, while the bird that had just been relieved did so less often. Normal preening behavior was not appreciably different from preening either while changing shifts or after chasing away an enemy, except that in the latter 2 instances more attention was paid to the plumage of the back. Once, a male approaching to change shifts was frightened by an unexpected noise in the blind (located 30 m from the nest). At first he stood motionless, but later calmed down and exhibited a rather odd preening behavior for about 5 minutes; the bird intently looked at his breast, flanks, and belly, touched his feathers with his bill, and then immediately raised his head up without continuing the preening.

On 1 very hot day I observed a remarkable phenomenon: After changing shifts, the male leaving the nest took water into his bill and, at 1st slowly but then with more rapid movements, splashed himself 10-15 times, 1st from 1 side and then from the other (while opening his bill and sometimes touching it to his plumage). After this the bird cleaned himself vigorously, paying particular attention to the places he had splashed. I have observed similar behavior in the white-naped crane (*G. vipio*), although this bird alternated usual preening behavior with splashing, taking water into its bill and opening it as it cleaned. On another occasion 2-3 hours before a heavy rain on 23 May 1978 the female, walking away from the nest, pulled up some sedge and threw it backwards and to 1 side. The stereotyped movements used in this behavior did not differ from those used in splashing water on feathers.

The entire procedure for changing incubation shifts lasted 3-28 minutes (10 minutes average). On the day before the 2nd chick hatched (at 2 nests) the incubation exchange lasted 14-45 minutes (26 average), and at 1 nest the male only relieved the female once in the morning, remaining 10-30 m from the nest for the remainder of the 24-hour period, and flying away to feed 3 times each for 1-2 hours. When he returned, the pair would graze together, feed the chick, preen, and catch flies. Then the female would sit on the nest, turning the egg beforehand, and the male would once again feed on cotton grass, doze, look around, and glance at the baby crane, often tilting its head

downwards while holding its neck in a nearly vertical position.

During the 1st days of the lives of the downy young, the adults took turns warming the chicks in dry areas from sunrise to 1900-2000 hours in the evening at intervals of 15-20 minutes. While 1 of the parents warmed the chicks the other gathered food nearby. Later 1 crane remained with the chicks while the other caught food 20-30 m away and, having caught something, would quickly approach and feed the young while the partner went off in search of food.

FEEDING TERRITORY OF THE PAIR, NEIGHBORS, AND ENEMIES

The feeding areas of nesting pairs during the incubation period were rather constant and were located (data from 4 nests) 600-1,500 m from the nests, on the most flooded areas of the nesting territory. One 1976 pair, nesting 600 m from the previous year's nest, fed in the same areas as in 1975. A pair frequently had 2-3 such areas of which often only 1 still existed when the eggs hatched; the other had dried up. The feeding areas' configuration coincided with the deepest parts of the marsh.

A feeding crane would walk slowly with its head down for 200-800 m, remaining for long periods in 1 place, making occasional movements of the bill. (Once, a pair that had not yet begun nesting, pecked for 30 minutes at numerous shells of small molluscs and at sedge rhizomes in a burned area.) The bird would stretch its neck periodically and look around, preen itself for a lengthy time, flap its wings, shake itself, doze off (slowly moving its bill until it just touched the straightened neck and turning its head slightly to the side). A sleeping white-naped crane assumes an identical pose. Having caught something, a crane would rinse its catch in water (sometimes several times) with rapid movements and only then would swallow it. Often it would catch flying horseflies or other flies by lunging sharply with its head and clapping its bill. Mosquitos would often land on the unfeathered areas of the bird's crown or on its eyes, at which point the bird would rub its head on its back, brushing off the insects.

The dimensions of the territory basically coincided with the size of the feeding area. Eastern white storks (*Ciconia boyciana*, usually 5-7 nests of this species were situated among the dry patches of woods surrounding the cranes' nesting marsh) and grey herons (*Ardea cinerea*) did not elicit any aggressive response from the cranes while feeding on the cranes' territories, although they often approached to within 3-10 m of the cranes. In 1975 a red-crowned crane did not react to the presence of a white-naped crane that during the course of its day at the feeding ground stayed at a distance of 300-600 m. (In 1975 about 12-15 non-breeding white-naped cranes [7-9 in 1976] were noted in the territory between the Bureya and Arkhara Rivers.) In 1976 a single *G. vipio* that had lost its partner often could be found on the territory of red-crowned cranes, and at the time of hatching became associated with the brood. When we visited this area 3 weeks later the white-naped crane remained next to the family of red-crowned cranes as it had previously. White-naped cranes often called in unison 500-800 m from the nests of red-crowned cranes and on 1 occasion the latter even called in reply. During August we observed pairs of different species feeding only 30-40 m apart.

The cranes seemed to remain indifferent to the majority of birds appearing or remaining on the nest-

ing area 20-300 m from the nest. Thus during the day eastern red-footed falcons (Erythropus amurensis) and buzzards (Buteo buteo), and at night long and short-eared owls (Asio otus and A. flammeus, respectively) would sometimes hunt above an incubating crane and a pied harrier (Circus melanoleucus) would often alight in the sedge 50 m away. Pairs of magpies (Pica pica) nested nearby in the wooded patches, and Japanese quail (Coturnix japonicus), Schrenk's bitterns (Ixobrychus eurhythmus), stonechats (Saxicola torquata), Pallas' grasshopper warblers (Locustella certhiola), lanceolated warblers (Locustella lanceolata), yellow-breasted buntings (Emberiza aureola), and grey-hooded buntings (E. fricata) were found on the same marsh.

Although the cranes did not display any antagonistic reactions to the marsh harrier (Circus aeruginosus) during incubation, they gave Unison and warning calls when this harrier appeared above a nest when a crane chick was standing several meters away. Red-crowned cranes living on the island of Hokkaido, Japan, often attacked black kites (Milvus korschun), buzzards, marsh harriers, and Pallas' sea eagles (Haliaeetus albicilla) flying near the nest or chicks (Masatomi and Kitagawa 1974).

Crows (Corvus corone) frequently followed feeding cranes; their nests were located in the wooded patches in slightly greater numbers than nests of the white stork. When they approached to within 3-10 m, the crane would open its bill, stretch its neck out, slightly lower its wings, and run straight at 1 of them. The crow would fly 25-30 m away and again alight in the sedge.

Throughout the nesting period the cranes were aggressive towards spotted eagles (Aquila clanga). (One spotted eagle nest was 300 m from a crane's nest.) Once an incubating male turned an egg and did not sit back down on the nest for 14 minutes, watching instead a spotted eagle flying about at a distance of 25-30 m, until the eagle was 900-1,000 m away. During the final days of incubation I noticed several aggressive displays. A female that had just been relieved was flying towards the feeding grounds when it unexpectedly landed in midflight, looked around for about 1 minute, then flew off in a semicircle and, stretching out its neck and clacking its bill, chased a spotted eagle (10 m above the ground) for 30 m off to 1 side of its incubating mate.

After this activity, the crane landed and began to preen itself. Later, flying in to change shifts, she assumed the neck-stretch 30 m from the nest, after noticing the spotted eagle circling and calling 130 m away. The cranes changed shifts after the eagle had flown some distance away. Sometime later the male crane attacked from the air a spotted eagle that had been sitting on the ground, landed where the eagle had been, and stood with the neck stretched forward. Then the bird preened himself and walked away gathering food. In all of these situations, 1 of the birds remained on the nest while its mate pursued the enemy.

In 1975-1976 wolves were common on the marshes of the Bureinck-Arkharinsk Plain, and we heard the howl of a wolf at twilight on 30 April and 24 May 1975, 800-1,000 m from a nest. In 1976 we observed a wolf on 3, 15, and 19 May 200 m from a nest of G. japonensis. A remarkable episode occurred on the cranes' feeding grounds during the 1st days of incubation, 1.2-1.5 km from a nest. The male crane noticed a wolf 600 m away, began to run, flew and landed 10-15 m from the wolf. Standing erect and turning slowly with his plumage sleeked tightly against his body, the crane

approached to within 6-8 m but the carnivore was searching for something between tussocks of sedge and seemingly paid no attention to the bird. At times the crane would walk slightly away and begin to preen itself, lowering its wings somewhat, but would then approach the wolf and once again sleek its plumage and stand erect. For approximately 30 minutes the crane followed the wolf, until they came to the border of the woods (about 700 m), and then the crane flew away to relieve his mate at the nest.

In early June 1975, local inhabitants released a large dog near a pair of red-crowned cranes with chicks. The birds allowed the dog to approach rather closely and then swiftly ran at it from both sides and pursued the dog for 200 m, attempting to peck at its sides. Frightened only of the people, the cranes then flew and returned to their chicks. Cranes might behave in a similar manner towards a wolf. However, taking into account the irregular occurrence of wolves on the Bureinsk-Arikharinsk lowlands in summer, I cannot consider wolves among the cranes' frequent enemies. Smaller carnivores--the fox, raccoon dog (Nyctereutes procyonoides), badger, and kolinsky (marten family)--do not present any danger to chicks or clutches in the presence of adults and are chased away by the cranes without difficulty. In Japan, stray cats and dogs often alarm the birds, but their influence is insignificant compared with that of man (Masatomi and Kitagawa 1974).

THE VOICE OF ADULTS

Archibald (1975) studied in detail the functional meaning and acoustic expression of crane vocalizations. I therefore have adopted the scheme and terminology of Archibald, comparing whenever possible the calls of the island and mainland populations of red-crowned cranes. (During field observations we attempted to describe precisely the various calls of the cranes and to evaluate comprehensively the situations in which the different vocalizations were used. We analyzed 360 calls given by approximately 20 individual cranes during the summer seasons of 1975 and 1976.)

1. Location Call. The quiet exchange between an incubating bird and a bird that had just fed sounded like a rather thin (audible for 600-700 m), soft "krr...krr..." Males of neighboring pairs, remaining on the feeding grounds to spend the night, exchanged similar calls. Red-crowned cranes did not answer the continual "location" calls of white-naped cranes on their nesting grounds.
2. Flight Intention Call and Flight Call. Resembles former in pitch, but slightly louder with a clear final vowel sound: "kroo...kroo..."
3. The Alarm Call. Very similar to the Location Call, but is significantly sharper, often repeated, and abrupt: "KRRR...KRRR..." It is given by a crane quickly leaving the nest and then flying closely past at the sudden appearance of a man 70 m away and by the adults when men examine the downy young.
4. The Guard Call--"KRRR000". Loudest, with the accent on the final "trumpeting portion," heard farther than 4-5 km. The call was given for several minutes after the appearance of a man near a nest with eggs or near a chick, and also when a crane probably crossed the boundary of their neighbor's territory while the neighbor fed with small chicks 150-300 m away.

5. The Agitation Call. The most unusual call, sounding like a coarse, fetal rumbling (audible no farther than 30-40 m), is probably produced by the passage of air across a rapidly opening (but not opened wide) and closing jaw. From a distance it was reminiscent of a cat's purring and was used as a warning to crows attempting to land on the nest, or was given when frightened. At twilight a flock of geese flew past a nest (at a height of 8-10 m) with a deafening noise, and the female quickly walked 10-15 m away from the clutch while making this rumbling sound. The birds gave a quieter version of this call a few times while turning eggs not long before the appearance of their chicks and when they changed shifts at the nest.

Archibald (1975) mentioned in his system of classification the so-called Nesting Call, noted during nest construction and before the eggs are laid, and proposed that the function of the nesting call was the synchronization of reproductive condition between partners. If the Agitation Call described above is the same as the Nesting Call, then the meaning of this auditory signal is probably wider, and expresses either mild excitement, e.g., due to nearness of a mate, or fright and warning in a circumstance of strange noise or a closely approaching enemy.

6. Unison Call (Walkinshaw 1973, Archibald 1975). During this call the cranes stood 1-3 m apart and, after turning to 1 side, quickly stretched their necks upward, pointed their bills upward and forward, and trumpeted. Then the male tilted his head back slightly and raised his folded wings above his back. The male and female vocalization differed. The male gave 5-6 calls separated by short intervals, each call similar to the preceding 1. The female began later, gave 1 call resembling her partner's, and then 2 short calls. The calls are represented schematically as follows: male--"KRRROO...KRRROO..."; female--"KRRROO--TOO--TOO..., KRRROO--TOO--TOO." The Unison Call was noted: during the morning hours (from sunrise to 0800 to 0900) at the beginning of incubation by various pairs (in this situation the call of 1 pair was often taken up in turn by several neighbors); during a change of shifts; immediately after 1 of the chicks hatched; on an occasion when a marsh harrier came close to a nest containing a young chick; and at the appearance of a man near the nest. In the latter 2 situations the cranes, after giving a series of Unison Calls, often began giving warning calls with the characteristic poses and then began preening.

Archibald (1975) noted that the Unison Calls of island and mainland populations are different (in cranes inhabiting the island of Hokkaido); for each long call of the male, 2-3 short calls of the female occur, not 1 long and 2-3 short calls as is peculiar to birds on the continent. Our analysis of more than 40 Unison Calls of 3 pairs confirms the correctness of Archibald's observation.

REACTIONS TO MAN

During the incubation period we examined 5 nests 8 times. We approached 2 of these nests 3 times during the 1st week of incubation, but not a single clutch was abandoned by the cranes, who usually returned to the nest 45-70 minutes after our departure. The reactions of various pairs of incubating birds to our appearance at the nest were approximately the same (data from 4 nests). After noticing a person from a

distance, the crane would raise its head quickly above the sedge and just as quickly conceal itself again. As the man approached to within 250-350 m the crane no longer lowered its head, and when the man was within 200 m the crane would stand up, walk 10-30 m away, take off, land 600-800 m away, and then walk slowly or stand with slightly lowered wings and head held high.

Sometimes the mate would fly to the 1st crane and they would walk together, stopping rarely, and describing an arc whose radius was 600-1,000 m as measured from the nest. On 1 occasion a crane arose from the nest and quickly walked away when I approached to within 300 m, and on another occasion it crouched down and began to run, then flew off. At 1 nest containing an egg and with a chick nearby, the adult cranes behaved as they had for the unhatched clutch, even when an observer appeared unexpectedly 90 m away.

As a man walked towards adult cranes with 2- to 4-day-old chicks, the adults began to walk away when the person approached within 300 m, and occasionally an adult would fly 200-400 m and land, while the 2nd adult would walk towards the 1st. Later they would stand 500 m away and give the guard call until the man had walked farther than 0.5 km away from the chicks or had concealed himself in the woods. When I appeared suddenly at 40-70 m the 2 parents would hurriedly walk away in different directions, calling anxiously, and would approach each other 200 m away. Then 1 of the cranes would fly in a circle 50 m from me and land near its mate, or they would take flight together and fly for 200-300 m, giving the Alarm Call, and land. Five to 10 minutes later they would stand 600 m away giving the Guard Call and would fly to their chicks immediately after our departure.

When accompanying 1- to 3-week-old young the female would walk in front while the male walked 20-30 m behind and looked around constantly. When a person appeared in an open area the female would increase her pace while her mate would stop and walk off to 1 side, acting as a decoy. If the observer continued to draw closer the male would stop and the female would leave the now concealed chicks and begin to bustle back and forth, sometimes breaking into a run. After awhile the birds would fly about giving the alarm call, land 200-300 m away, assume the characteristic pose, and give Guard Calls. In a similar situation a family of cranes with 2-month-old young would walk away so rapidly that the distance from the man would remain constant or even increase.

DANCES

This phenomenon has been observed in red-crowned cranes living on Hokkaido in late winter or early spring (Walkinshaw 1973). According to local inhabitants, dances of the continental population have been noted in the central Amur area (in the environs of the village of Ukrainok) during the final weeks of October. On 2 occasions I observed elements of dances connected with a disturbance to the birds by the appearance of a person near a nest containing a clutch or downy young.

An incubating female once stood up after having seen an observer, crouched, walked quickly away from the nest, flew after walking 30-40 m, made a semicircle, and landed 700 m away near its mate. The male began to bow, raising his wings above his back (about 8-10 times). He then jumped up, flapping his wings, approaching his mate (who was stamping her feet in place), and then drawing away from her. During jumps the wings were positioned alternately with 1 up and

the other down, and with every jump the position of the wings reversed. After 2-3 minutes they stopped 5 m away from 1 another and gave 5-6 Unison Calls and a few Guard Calls.

In another instance the birds led us away from their hiding chicks, bowing with lowered wings. One of them would jump up from time to time and turn 90° in mid air, flapping its wings 2-3 times. During a jump the bird held its body vertically, stretched its legs forward, and gave the Guard Call (which was sometimes answered by a crane from a neighboring pair 1 km away). When I stopped, the birds walked away, slowing their pace for 500 m; if I then continued to approach, the whole performance was repeated. Leading me away in this manner for 1 km, the cranes then flew 900 m off to 1 side. Dances in similar situations were also observed by Y. B. Shibnev.

POSTNESTING LIFE, FLIGHT TO THE WINTERING GROUNDS, AND FACTORS LIMITING POPULATION SIZE

After the chicks had hatched, all birds did not behave similarly. If food was sufficient near the nest, the brood remained on the pair's feeding territory for 1-2 weeks, but in the event of disturbance the adults led the chicks away to the most distant areas of the marsh on the 1st day after hatching. Between mid-June and late July the marshes in the region of the cranes' nests dried up (1974-1975) and the birds moved to areas which were wetter and richer in food. Thus, at 3 nests we encountered broods for 2 weeks after hatching of the youngest chick, and at 1 nest for only 4 days. The territory of yet another pair was abandoned on the day following the appearance of the 2nd chick, due to frequent disturbance by a herd of grazing cattle.

From the end of August to the beginning of September the cranes formed groups of 4 to 8 individuals and often fed 50-200 m from 1 another in flooded areas near lakes. Hunting activity in the latter part of August (1974-1975) and the initiation of agricultural activity forced the cranes to move constantly around the region in search of safe feeding areas. The ratio of adults to young in these groups was approximately 3:1, although if an observer considers the 100% hatching success (data for 1975) and the presence of sub-adult and unpaired individuals, the ratio should have approached 2:1 (26:14). Thus, a significant percentage of chicks (30-40%) die before fledging.

By mid-September a noticeable decrease in numbers of cranes due to migration had not been observed throughout the entire lowland area between the Bureya and Khigan Rivers. The autumn migration probably begins in October. According to the data of local correspondents the last birds in 1975 were seen on 23 October, a flock of 3 remaining at that time on a harvested field near Severnoye village. In 1976, 5 birds were observed on 28 October on the ice of the eastern part of Dolgoye Lake, and were not noted later. According to N. S. Pan'kin's observations, the cranes rarely remain in the lower reaches of the Bureya River as late as the 2nd week of November.

On the Bureinsk-Arkharinsk lowland the following factors caused a decrease in red-crowned crane populations.

1. Spring grass fires that continued into the reproductive season until 1 June in 1975 and to the end of May in 1976.
2. The grazing of about 2,400 head of cattle, in the

center of the nesting grounds, along with the presence of armed herdsman and dogs.

3. Poaching, aggravated by the beginning of the autumn hunt, which is too early for this region. In the Arkharinsk region I did not meet a hunter who had not, at least once, shot at the cranes.
4. Autumn fires that often reduced to a minimum the number of areas suitable for nesting the following year.
5. Among natural mortality causes it is worth mentioning morning frosts that probably lead at times to the death of chicks and eggs whenever adults are frightened away. The average date of the last frost (air temperature) in the Arkharinsk district (data from many years) falls on 7 May, and the average date of the last frost in the soil occurs on 25 May.

Observations in 1976 substantiate the simultaneous influence of weather and anthropogenic factors on the population of red-crowned cranes inhabiting the lower reaches of the Bureya River. A nearly snowless winter caused the lakes and streams to freeze solid, a massive fish kill, virtual absence of water in the marshes, and the widespread burning of the previous year's sedge growth. The fires deprived the cranes of nest habitat and led to a springtime dearth of food. The cranes were forced to feed on harvested soybean and corn fields near humans, where they were almost never seen in 1974-1975. As a result, in 1976, 1 pair of cranes nested on the marshy lowlands where 8 pairs had nested in 1975, occupying the only patch of unburned sedge (200 X 600 m). Three neighboring pairs retained their nesting areas of the previous year from the time of their arrival until 1 May. I heard their Unison Calls nearly every morning at this time.

Intensive draining and grazing on the marshes represents a direct and ever-increasing threat to the existence of these rare birds by leading to the complete destruction of their primordial nesting and feeding habitat. The impact on the hydrology of the lower reaches of the Bureya River, resulting from the construction of the proposed hydroelectric power station near the Talakansky line, would mean catastrophe for the cranes. Considering what has been said above, due to the impact of man, red-crowned cranes may continue to inhabit this region for no longer than a decade.

In order to preserve what is nearly the last intact nesting grounds of the red-crowned crane on the continent it is essential to withdraw the Bureinsk-Arkharinsk lowlands from agricultural use at once, with the exception of plowed land, and to designate the area as a preserve.

I express my gratitude to A. A. Mezheniy (a student at Leningrad State University) without whose active participation this work would not have been completed, and also to I. A. Neufeldt and K. A. Yudin, whose constant consultations offered me invaluable assistance. I also sincerely thank Dr. G. W. Archibald and L. Walkinshaw (USA), and Dr. H. Masatomi (Japan), who sent me reprints of their publications that were indispensable to the writing of this article.

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THE RED-CROWNED CRANE

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PAST DISTRIBUTION IN JAPAN

About 200 Tanchos (red-crowned crane, *Grus japonensis*) reside in eastern Hokkaido, Japan, and occasionally a straggler will come to Kyushu via the Korean peninsula. But the study of various old bibliographies and paintings makes me believe that Tancho was probably not uncommon in Japan, was found mainly in eastern and northern Honshu during winter, and commonly nested even in southwestern Hokkaido.

In a colossal anthology "Mannyoshu," writings selected from the 7th to 8th century, 46 Japanese short poems (*waka*) are composed about the crane-like birds called *Tazu*. This bird was apparently not rare in Japan in that period, but it may be true that some of the *Tazu* discussed in the anthology are not cranes but swans, storks, or herons. It is very difficult to determine the species involved even if most *Tazu* were cranes.

Tancho appears in several traditions (especially those handed down in Kushiro district) of the aborigines, the Ainus, who lack any original writings of their own. It is difficult to determine when the legends originated. One tale says that a Tancho's egg was incubated and the chick hand-reared by an Ainu woman in Ishikari, the western lowland of Hokkaido. The scholars Terashima and Kaibara wrote several short notes about Tancho in their iconographical encyclopedia or natural history monographs published in the early 18th century. The monographs specifically indicated that Tancho lived in Matsumae, southern Hokkaido, and not in western Japan and Korea.

Some Ainus who were offering 2 Tanchos as tribute to their subjugators at Fukuyama, the southern tip of Hokkaido, were drawn in a genre painting in the late 17th century. Because of the legend that these Ainus were of the western tribe, the Tanchos must have been caught not far from Fukuyama in spring 1686.

Matsumae reported in his history of western Hokkaido that there were several kinds of cranes, especially many Tanchos. A clansman of the Matsumae Territory hunted about 300 Tanchos and frequently watched their courtship, other breeding behavior, nests, eggs, and young. At the same period in a book of travels to Hokkaido it was recorded that Tanchos lived in flocks at southern Hokkaido and the salted meat was exported to other territories. In the mid-19th century many cranes, possibly Tancho, were observed in the Ishikari Plain, western Hokkaido and 2 (a pair?) at Otanoshike, eastern Hokkaido in mid-summer. Thus, it may be inferred that Tancho commonly nested in southwestern and eastern Hokkaido until about 100 years ago. Moreover, judged from the place names, probably wintering areas of the cranes, Tancho must have lived or bred along the south coast of Hokkaido, from Tomakomai to Nemuro.

On the other hand, many artists painted Tancho on walls, sliding doors, folding screens, and elsewhere in Honshu from the beginning of the 15th to the 19th centuries, although some of those Tanchos were probably captives. Hokusai, a famous painter, sketched Tancho with white-naped cranes (*Grus vipio*) in the

Soshu-Umezawa scene (central Japan) of his serial landscape woodcut prints (1823-1830). The refuges for *Shogun* were established near Tokyo in the 18th century, and many birds, including the hooded (*G. monachus*) and white-naped cranes, were hunted with hawks, but Tancho was restricted from hunting as a favored bird. Those facts may indicate that some Tanchos wintered in central Japan until the last half of the 19th century.

Nevertheless, the rapid decrease of the population resulted from the lack of protection by the Meiji Restoration. Since the middle of the 19th century, cranes have become very uncommon in central and northern Honshu. But in Hokkaido many of them seemed to be on the Ishikari Plain (chiefly in Chitose) and sometimes were hunted in eastern Hokkaido (Akan). Blakiston also recorded a Tancho caught near Sapporo 1 year in January. The facts that several bans were issued to protect cranes nesting in the Ishikari lowland in the early Meiji era (Inoue 1972) and that a cat holding a chick of the Tancho in its mouth came back to a home near Sapporo in 1890 confirm the nesting of Tancho in western Hokkaido until 1890.

Tanchos were occasionally found near Tokyo until the end of the 19th century, but they were rarely seen in the Ishikari Plain or in Honshu by the 1910's. Some authoritative ornithologists assumed that they had been extirpated in Japan. But Tanchos were found nesting at Kushiro in 1924 (Saito 1926), and about 20 birds were estimated in the Kushiro Marsh. The exact size of the population at that time, however, is unknown due to lack of regular investigations in eastern Hokkaido, where Tancho is now widely distributed.

Furthermore, a few were seen at Kitami, Hokkaido, in September in 1926 and 1937. In Honshu we find the following records: Miyagi Prefecture in March 1922, Ishikawa Prefecture (the Noto Peninsula) in 1927, Niigata Prefecture in 1935, Fukushima Prefecture (Oze) around 1930, Shiga Prefecture in May 1943, Sado Island in 1947, and Fukushima Prefecture in 1949 (Takatsukasa 1967).

Many white-naped and hooded cranes have come to Kyushu via the Korean Peninsula to winter for more than 1,000 years. Probably the Tancho of the continent may have migrated to Kyushu and western Honshu together with flocks of those cranes mentioned above, but credible records are only available for after the middle of the 19th century. Thereafter a few intermittently came in winter; 1 appeared at Izumi, southern Kyushu, in 1967-1968.

PAST DISTRIBUTION OUTSIDE OF JAPAN

Many red-crowned cranes may have spent the winter in Korea for countless years, although the exact numbers are still unknown. In the 1880's they wintered in a flock and some were collected in the northern region of the peninsula (Takatsukasa 1967). Despite the declining status of Tancho in Japan in the 1910's, they were fairly common and were collected on the west side of the Korean peninsula. Before 1945, flocks of hundreds to thousands of them were often found in Pyongan Bukdo, Pyongan Namdo, and Whanghae Do (northern Korea). They moved south when the ground and marshes froze, wintering even in the south margin of

¹Written in 1974.

the peninsula in December. There is no definite record of nesting in Korea. Before the Korean War the red-crowned crane was not uncommon in middle and southern Korea.

In China some specimens were collected at Haerhpín and Chichihaerh, the northeastern division of China (Manchuria) in 1925-1926. The birds seemed to nest along the basin of the Sungali River in China and at Pei-tai-ho near Chin-huang-*tao* in fall and spring, north of Yangtze River in winter, and as a straggler from Kwangtung in South China and Formosa in 1932.

The marshes along the Amur and the Ussuri in Russia were their breeding areas. Those nest areas at Lake Khanka and along the Lefu River have been well known since the last half of the 19th century. Some stragglers were recorded at Darasun, Lake Gagol in Tuva Autonomous Region, and Khadzhakazhik Pass. Outside of the continent the birds were seen several times at the Lake Tokotan near Randomari in Saghalien, and a specimen was collected at Moneron Island in 1935.

PRESENT DISTRIBUTION IN JAPAN

Tancho was found again in Kushiro in 1924, but no survey was made. Thereafter its population increased little and its habitat seemed to have been restricted within Kushiro District except for some stragglers to other districts or prefectures. However, the number of birds has increased since 1952 as a result of artificial feeding in winter. The relative size of population or distribution area gradually became clear from the annual census in winter and incomplete surveys of breeding grounds.

Although some farmers noted that Tancho has lived in Nemuro since the 1910's-1920's, still a breeding pair (at Lake Parasan, Nemuro District) was not confirmed until 1953. Many other breeding pairs were found in Kushiro, Nemuro, and the other districts by

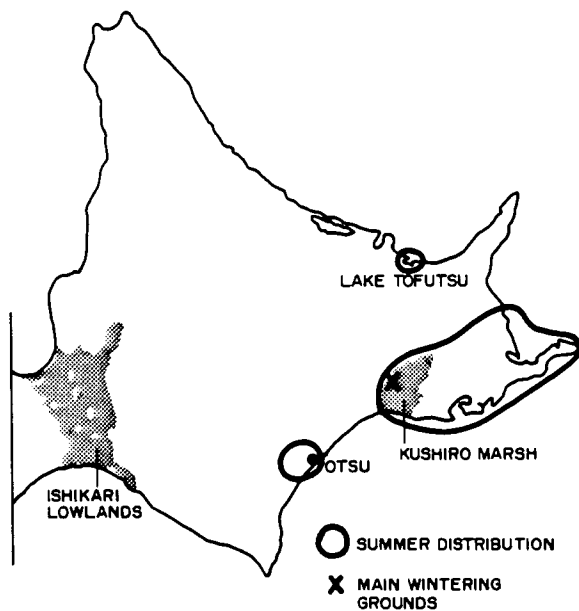


Fig. 1. Distribution of red-crowned crane in Hokkaido.

aerial and terrestrial surveys in 1972 (Archibald 1972).

The present breeding area (Fig. 1), roughly speaking, includes the marshes near the Otsu River mouth (Tokachi District); the Kushiro Marsh and its neighboring lakes and lowlands; areas along the Bekanbeushi River; the Kiritappu Marsh (Kushiro District); the marshes in the Nemuro Peninsula; Lake Furen; along the Nishibetsu and Shibetsu Rivers; and the lowlands between both rivers (Nemuro District). A young pair has currently settled at Lake Tofutsu (Abashiri District) and is expected to nest there this year (1974).

Main wintering places are relatively restricted to several areas of Kushiro District: near Akan Town in Tsurui Village. Winter flocks consisting of about 40-80 birds, but not stable in flock size, are formed around the feeding stations in these places. A few cranes were found in the southern (Yakumo) and western parts (Hidaka District) of Hokkaido in the 1950's, but lately we have had no records, except for some stragglers to Kyushu, from Hokkaido or Honshu since 1949.

PRESENT DISTRIBUTION OUTSIDE OF JAPAN

Current records on the bird's distribution in the continent are not plentiful. The present extent of nesting area and the population size in the Maritime Territory seemed to be much less than those mentioned formerly. The breeding area now on the continent is only the east side of Lake Khanka. A little nesting activity may occur along the Sungali River, although there is no direct information from China.

After the Korean War the population of flocks wintering in South Korea is reported to have steadily declined, and there are only a few sight records in Kangwon Do and Cholla Namdo, and capture records in Kynggi Do and Chungchung Bukdo. But several birds were often found near the Demilitarized Zone during recent years. It has been reported that many white cranes (*G. japonensis*?) wintered in North Korea, especially in Hwanghai Namdo, even after the Korean War, although we have no confirmation at present.

MIGRATION

Most of the Tancho in Hokkaido move less than 150 km between nesting and wintering areas in spring and fall. They begin to move in late February, and almost all adults or pairs depart from the feeding stations to their nesting areas, establishing their own territories in the lowlands until early April. Chicks of the previous year and some subadults generally remain at the winter area until mid- or late-April. Many of those juveniles appear in Nemuro in May or early June and disperse into the marshes.

Some Tanchos come back to the wintering area in early September, but most of them seem to leave their summer habitat during October and November. Some cranes seen in early December in Nemuro disappeared soon thereafter, so the movement towards wintering areas must generally end by mid-December. Tancho leave the winter feeding stations in pairs or small flocks of nonbreeders in spring and usually return as pairs or family units in fall.

Generally, they do not return directly to wintering areas, but they frequently land en route and forage around cornfields, river or lake sides, and marshes, sometimes fighting with other Tancho who still defend an area as their territory. Nevertheless, an outstanding phenomenon is that there are some pairs or

families that never leave their habitats, even in the nonbreeding season, and maintain the territory throughout the year. Such pairs occur in Takkobu, Shimochanbetsu in Kushiro District, Tofutsu in Abashiri District, and maybe even in Nemuro District.

Some of the Tanchos observed in southern Hokkaido and northern Honshu (mentioned before) in nonbreeding seasons from the 1920's to the early 1950's may have migrated from eastern Hokkaido, because there was not much winter feeding then compared to the successful feeding after 1952. Many also may have migrated to Honshu when they nested in the south and west regions of Hokkaido. In Siberia, Tancho appeared in the Maritime Territory from early March to mid-April in small groups, and their autumnal departure flights continued from August to December.

In China, Tanchos passed around latitude 39°N, flying southward from late October to mid-November and flying northward in March. Unfortunately, these records are not recent. A flock of about 50 individuals including juveniles appeared between the Tumen River and Talimi Lake and stayed there until 21 March 1961, though there has been no extensive survey of the migration of Tancho on the continent. A flock of 11 birds flew over on 1 April 1962, and a small flock was observed in 1961 at Lake Khanka at the end of March. Only 2 areas, the plains around the mouths of the Tumen and Suifun Rivers, are known to be the temporary rest areas during spring migration in the Maritime Territory. No wintering cranes have been observed around Lake Khanka; thus, all are considered migrants (Litwinenko, pers. comm.).

Autumnal migration of Tancho in Korea usually occurred in September. The birds appeared in South Korea in early November. Gradually moving southwards, they arrived at the southern end of the peninsula in December-January, probably a few crossing the sea to Japan with hooded and white-naped cranes. Spring movements northward were noticed in central Korea after late February, and by late March the cranes had left southern Korea.

HABITAT

The main habitat requirements for nesting are lakes, ponds or rivers, nesting spots with nest materials, and wetlands with open places partly uncovered by water (Masatomi 1973). Woods (mainly alder), roads, railways, bridges, buildings such as farmhouses, cultivated fields, or grasslands are sometimes included in the home ranges (Fig. 2). Therefore, the general aspects differ in each.

The conditions of the actual nesting sites vary in every habitat, but they can be broadly classified into 3 types: open forest, fen with reeds growing luxuriantly, and open wetland (Masatomi 1970). Furthermore, the vegetation of nesting sites is roughly divided into several categories.

Alder-sedge association is the 1st category. *Alnus japonica* var. *arguta* less than 2.5 m high makes a slightly dense forest of which the floor is covered with various sedges sometimes forming characteristic hummocks, gale (*Myrica gale* var. *tomentosum*), bog moss (*Sphagnum*), and sparse reeds. A nest under such conditions is unusual.

The 2nd type of nest site is characterized by low moor or thick fen vegetation of the reed (*Phragmitetum communis*) and may be classified into several subtypes by its density and appearance of the surrounding vege-

tation. For example, some nest sites are sparsely wooded with alders, while others have no trees within at least 200 m. One nest site may be covered almost entirely with reed, while another site contains few reed in a reed-sedge community that includes various sedges, bogmoss, and other plants.

In the 3rd type, the reed density is low (Masatomi 1970) and sedges or bogmoss become dominant. No pair has been found nesting in such high moor as the bogmoss-cranberry association, but it was reported that a pair had tried to construct its nest on a drier site near a cultivated field (Saito 1926). Each situation differs in how constituents of the home ranges are utilized.

POPULATION

Many Tanchos may have been in Hokkaido until the late 18th century. About 300 Tanchos were recorded caught by Okada, but the dates when he trapped are uncertain. It has also been reported that there were large assemblies of Tanchos among the Ainu (aborigines).

In 1924 the population in the Kushiro Marsh was estimated to be less than 20, and a flock of 18 Tanchos was observed at 1 place in the early 1920's (Saito 1926). Kuzu (1928) also presumed there were about 25 red-crowned cranes in Kushiro, based on hearsay evidence from the inhabitants. Thereafter, the population size, occasionally estimated at slightly more than 30, did not fluctuate significantly for about 2 decades. Since then the population has gradually increased, apparently in response to the feeding of corn in winter.

The census of Tancho by school children in eastern Hokkaido has been conducted every December since 1952 (Table 1). It is inappropriate to say that the counts in the early 1950's were very accurate because some areas were not censused and methods were inadequate. In recent years the cranes also have been drawn to central locations by the feeding, and this has made the survey more complete.

Together with the actual fluctuation of population, the number reported each year may include observational errors. For example, the rapid increase in 1972 may be explained by successful reproduction, but presumably the counting errors also underestimated the numbers in 1971. Nevertheless, the population of Tanchos in Hokkaido has apparently increased largely due to the reduction of mortality in winter. Tancho numbers increased rapidly each winter, because of the successful nesting, until around 1960, and since then the population has been relatively stable.

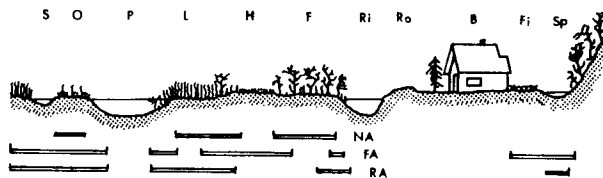


Fig. 2. Habitat components used by red-crowned cranes (S = shallow stream; L = low moor; Ri = river; Fi = field; NA = nesting area; O = open place, H = high moor; Ro = road or rail road; Sp = spring; FA = feeding area; P = pond or lake; F = forest or grove; B = building; Hi = hill; RA = roosting area).

CONSERVATION

Tancho is more or less protected in Japan, not by law, but as a symbol of longevity from old times, probably under the influence of Chinese belief. During the time of the Tokugawa Shogunate (17th-19th centuries), Tanchos were safely preserved in the hunting-prohibited areas established for the highest governors, and the cranes were even exempted from hunting using hawks. Those who killed Tanchos had committed a grave offense. In Hokkaido, however, no such restrictions existed; thus, many cranes were hunted or caught with snares and were exported to the other districts as salted meat.

Meanwhile, as they decreased in number, the 1st ordinance for the prohibition of crane hunting was issued by the local government in 1889. The marshes and bogs in Sapporo, Chitose, Yufutsu, Yubari, and Sorachi were designated as nesting habitats of Tancho. In 1890, hunting of all birds, and transfer or lease of government lands to private ownership, were prohibited in the designated areas. In 1892 Tancho was declared protected by the central government (Inoue 1972).

Extinction of Tancho in central and southern Hokkaido at the beginning of the present century may be attributed to the gradual expansion of rice farming, which destroyed marshes and peatlands that were crane habitat.

After Tancho's existence was confirmed in Kushiro, about 1,200 ha of this habitat was assigned as a hunting-prohibited area by the Ministry of Agriculture and Forestry in 1925. Ten years later a local nesting area of about 2,700 ha, and Tanchos who were living in Kushiro, were nominated as 1 of the natural monuments.

Several years after World War II the area was raised to a higher rank, i.e., a special natural monument, which should receive more rigorous legal protection. Later, Tancho everywhere in Japan were designated as a special natural monument, and the enlarged sanctuary, about 5,000 ha, was kept separately as a natural monument for its valuable wetland vegetation.

Tancho is now legally protected by several laws: the cultural properties protection law; the law concerning protection of wildlife and hunting; the law

Table 1. Number of Tanchos counted in December, 1952-1973.

Year	Number	Year	Number
1952	33	1963	147
1953	42	1964	154
1954	52	1965	172
1955	61	1966	170
1956	76	1967	200
1957	92	1968	171
1958	125	1969	212
1959	139	1970	179
1960	172	1971	147
1961	175	1972	222
1962	184	1973	233

relative to the regulation of transfer of special birds and others; the convention between the government of Japan and the government of the United States of America for the protection of migratory birds and birds in danger of extinction, and their environment; and a somewhat similar convention between the USSR and Japan was also recently signed. The 1st law mentioned is enforced under the auspices of the Cultural Agency; the others are under the Environment Agency. Therefore, those 2 government agencies participate in protection of 1 bird.

Legal control of the conservation of habitat is still insufficient. Only a portion of the Kushiro and Kiritappu marshes, including some breeding habitats, has been declared a natural monument to protect the vegetation. Moreover, several wildlife protection areas and prefectural parks cover some habitats. People are generally prohibited from entering the designated areas and damaging the habitat. It is illegal, even in unprotected areas, to approach Tancho's nest or disturb its breeding activities.

The Society for the Preservation of Tancho, which was organized in Kushiro in 1935, continuously has tried to protect Tancho in various ways, although population growth was not achieved until the 1950's, when the winter feeding program succeeded. Many farmers and school children now give corn to wintering or migrating Tanchos at about 20 feeding stations from September to April. This activity is supported by a subsidy from the prefectural government and by donations from many people. The counts of Tancho have been made annually in early December since 1952, mainly by school children. For example, about 5,100 persons participated in the survey in 1973.

Several Tanchos, a maximum of 20, have died annually due to collisions with electric power lines that border the winter feeding stations. Colored plastic plates or cylinders were attached to the lines, and this technique is considered helpful because collisions with the lines are less frequent. These preventive measures may slightly increase the population level of Tancho.

The Kushiro Natural Crane Park was dedicated with 5 males in the suburb of Kushiro in 1958, to popularize the preservation of Tancho, to feed wintering cranes lured into the park, and to study Tancho. Some wild females paired with the males and successfully nested. Artificial incubation and rearing are also successful, and now about 20 red-crowned cranes are kept in the park.

In South Korea, Tancho was sometimes illegally caught until the 1960's, but it is protected by the law concerning protection of wildlife and hunting and since 1968 is a natural monument under the cultural properties protection law. Tancho is also given legal protection in North Korea, where the areas of South Hwanghai Province are designated as a natural monument for preservation of wintering cranes. The USSR also prohibits hunting of this bird and enforces the rules of the convention between the USSR and Japan.

PROBLEMS FACING SPECIES SURVIVAL

The population size in Hokkaido has remained relatively unchanged for the past 15 years owing to the successful winter feeding. But a major problem is failure to conserve habitat: namely, (1) drainage of wetlands or marshes, (2) the clear-cutting of trees from the hills surrounding the crane's breeding areas, and (3) riparian works that are unmindful of marsh

preservation. This situation at Hokkaido is similar to what happened in the Ishikari lowland, where many breeding Tanchos were extirpated by agricultural development at the beginning of the 20th century. For example, Otanoshike, 1 of the popular Tancho habitats located about 16 km east of Kishiro, where the Tancho's summer life was 1st recorded in 1857, and in which much ecological knowledge or valuable photographs were obtained during recent years, was almost destroyed in 1972-1973 by reclamation for industrial use.

Breeding areas situated near the Kushiro Marsh are vulnerable to development, and the habitats in Akkeshi, Hamanaka, and Nemuro are also included in a program of agricultural or other development.

SOLUTION AND ACTION

Various scientific surveys are necessary to solve the following 2 problems: how to preserve Tancho and how to maintain its habitats. Besides several personal studies, 2 research projects have been carried out by the government. One study was conducted by the Cultural Agency from 1972-1974 to record Tancho's life history. The project had a budget of about 1 million yen a year. Before this study, population surveys had been made only in December. An objective of this project was to census the breeding and nonbreeding birds and their distribution in eastern Hokkaido by use of several aerial surveys during the summer. The number of cranes counted in summer was similar to the results of the winter surveys.

Another survey was promoted by the Environment Agency in 1972-1974 and supported by about 8 million yen a year. This project was designed to determine the effects of various developments on the ecosystem and Tancho, and to make plans for habitat preservation. The research was conducted in Kushiro in 1973, and in Nemuro in the last year of the program under the management of the World Wildlife Fund Japan Committee.

CAPTIVE BREEDING PROGRAM

According to a census of Tancho in captivity (Asano, February 1973), 58 birds were captive worldwide, excluding China and others. Some of these facilities that keep cranes, e.g., Carl-Hagenbeck--Munchener, Rotterdam--Whipsnade, and International Crane Foundation--Honolulu, exchange or loan Tanchos to each other, and several have succeeded in breeding.

In Japan, 6 zoos or parks keep Tanchos; artificial

incubation and rearing was first successful at the Ueno Zoo directed by Koga in 1954, but recently neither artificial nor natural breedings in zoos have brought about good results. The Kushiro Natural Crane Park also succeeded in artificial and natural breeding arranged by Takahashi (chief breeder) within the last decade. Ten cranes, half of the Tanchos kept in the park, were produced there. This park will be transferred within a few years to a more suitable, larger site in the neighborhood of Kushiro Zoo. Then park personnel plan to expand their program of breeding cranes. But a systematic program for Tancho breeding in captivity has not yet been planned in Japan.

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POPULATION OF RED-CROWNED CRANES IN HOKKAIDO

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Fluctuations in populations of red-crowned cranes (*Grus japonensis*; Tancho in Japanese) in Japan are very similar to those of another population on the mainland (USSR and China), decreasing during the most recent 1 or 2 centuries (Masatomi 1979, 1980). The number of Tanchos, however, is fortunately recovering because of the efficacious protective activities in Hokkaido during the last 3 decades. This paper describes the presumed historical population size and the population growth since artificial feeding began. Reproductive rates are also discussed briefly.

PAST POPULATION SIZE

Tancho certainly had been hunted for centuries by the native Ainu of Hokkaido, but the Ainu had probably not killed many through the 16th century, when the Japanese ruled them and settled there a new clan of the Tokugawa Government. Since the 17th century the population of Tanchos in Hokkaido seems to have been severely impacted by hunting. Carcasses of many Tanchos were salted and shipped to other areas.

Agricultural development and colonization, supported by the policies of the Meiji Government, also had been started to drain the lowlands in southern and, later, in central Hokkaido. Thus, the rapid spread of cultivated lands (mostly paddy fields) has caused destruction of breeding and wintering habitats since the late 19th century (Fig. 1). In fact, since its last reliable nesting activities recorded near Sapporo in 1890 (Inukai 1943), Tancho has been extinct from central Hokkaido, except for infrequent appearances of a few wanderers.

Temperatures rather cool for rice culture discouraged converting wetlands into paddy fields in eastern Hokkaido and consequently reserved these marginal breeding grounds and maintained a small population, about 20 to 40 birds, until the early 1950's.

The area of habitats occupied by this tiny population cannot be accurately estimated. But if the present area of habitat occupied by about 250 individuals is conveniently used to calculate the population

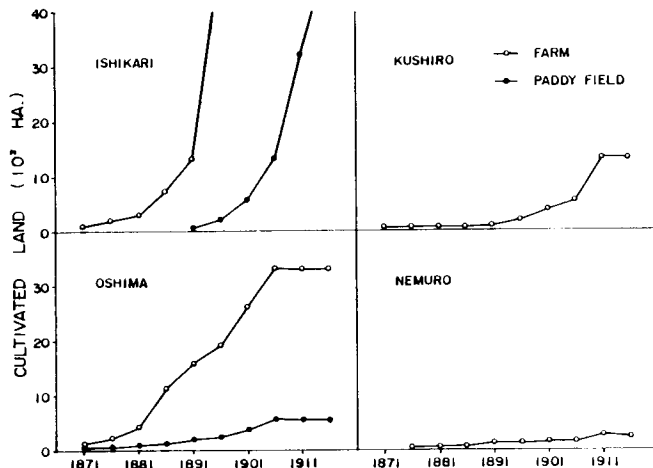


Fig. 1. Development of cultivated areas in several districts (Ishikari, central Hokkaido; Oshima, southern Hokkaido; Kushiro and Nemuro, eastern Hokkaido).

density of Tancho (also the historical peatlands in Hokkaido, except the northern parts, are believed to be former nesting habitat), the past maximum number of Tanchos might be only 147. This estimated population size, however, would be inappropriately small, because the carrying capacity (K) in eastern Hokkaido, which has very severe climatic conditions that would depress the survival rate in winter, must be lower than those of central and southern Hokkaido.

Many individuals nesting in eastern and other areas would probably prefer more moderate climatic environments in winter; therefore, K would not be as low in all of Hokkaido as in the east. This assumption is substantiated by several old descriptions that the Tanchos were common in swamps and formed large flocks in winter (Hezutsu 1784).

Using the next simple calculation, as an example, the historical population before its considerable decline might have consisted of about 843 to 917 individuals on Hokkaido. Because

$$P_1/W_1 = P_2/W_2$$

where P_1 is the present population (230 to 250), P_2 is the historical population, W_1 is the present area of habitat (30,000 ha), and W_2 is the past peatland area (110,000 ha).

But the present population has been effectively supported by artificial feeding, which has probably increased the survival rate in winter. There are not sufficient natural food supplies to support such a large population in frozen fields of the present wintering grounds. Thus, it is necessary to consider the present unique conditions when estimating past populations. Conditions that maintain relatively high population levels are increased carrying capacities in central and southern Hokkaido, a short migration route to wintering areas, and artificial feeding. Factors limiting the populations include nonmigratory residence in hazardous areas, past continuous hunting, and various recent human impacts. Therefore, it is difficult to estimate the exact size of past populations from the present population status of Tanchos that are intensively managed by man.

However, the density of the wild breeding population, migrating and not being fed artificially, is 0.68-0.72 cranes/km² at the censused areas on the continent (Ma and Xu 1980), and this deviates little from the value of 0.78 crane/km² calculated in Hokkaido. In conclusion, the historical population of Tanchos is estimated at 600 to 900 cranes in Hokkaido before hunting and land development diminished its size.

POPULATION GROWTH

The census of Tanchos has been sponsored every winter since 1952 by the Hokkaido Educational Committee. The results, however, do not always accurately reveal the numbers of wild Tanchos. First, the count includes Tanchos kept in Kushiro Crane Park since 1958, and the number in captivity gradually increased until it has become 10% of the whole population. Second, grade school children and junior high school students count the cranes; consequently, there have sometimes

been counting errors. There also have been occasional errors by the Educational Committee when they summarized the original data.

The final and most important factor influencing census results is the annual status of Tanchos' appearance in the areas where they are easily found at the census time. In 1966, for example, 165 individuals were counted (139 adults and subadults and 26 young-of-the-year). Even if all 165 survived until the next year, their numbers would not explain the 171 adults and subadults counted in 1967. The same phenomena has occurred on several occasions (Table 1).

The census has usually been made annually on 5 December. But the number of cranes in the counting areas on 5 December is largely controlled by environmental factors, chiefly weather and food abundance in the nesting habitat. These environmental factors have affected the annual numbers counted to such an extent that they have hidden any fluctuation in the real number of Tanchos. The past census results ultimately prove only the complexity of the annual fluctuation of the population and document the status of aggregation on the wintering grounds every early December.

Although the official numbers of Tanchos have not always indicated the true population, the arithmetic plots of crane numbers (exclusive of the captive individuals) indicate a sigmoid growth form (Fig. 2). The rapid increase in population from 1952 to the 1960's was obviously due to the artificial feeding program, which probably eliminated any shortages of food (which had been 1 of the most serious factors limiting the population) and increased survival in winter.

The growth curve has been in a state of general equilibrium since the 1960's, but it shows a slight increase again since 1972-1973. This recent increase is probably partly due to the efforts of local people in preventing the cranes' collision with electric wires, which had previously caused the death of about 20 cranes annually, almost 10% of the population.

The limiting factors causing the relative stability of the population are not yet analyzed sufficiently, but those nesting wetlands not affected by humans are decreasing (there were vast virgin lowlands available for the rapid population growth in the 1950's). Recently Tanchos have expanded their distribution in eastern Hokkaido, and the number of breeding pairs in new habitats is increasing slowly in Tokachi District. But these areas are usually not far from pastures or other fields of agricultural and fishery activities. Thus, I cannot discard the possibility that these habitat conditions may be of marginal quality and adversely affected by indirect human impact, thereby preventing swift expansion of the population.

REPRODUCTIVE RATES

Reproductive rates have been calculated from data collected 1969 to 1971 and intermittently 1957-1967 and 1973-1974. Average clutch size was 1.83 for 52 nests, with yearly ranges of 1.63 in 1970 to 2.00 in 1973. This clutch size is slightly below that of the greater sandhill crane (*G. canadensis tabida*; Littlefield and Ryder 1968, Walkinshaw 1973).

An average of 79% of eggs, which were normally incubated, hatched (68.8% in 1969 to 91.7% in 1970). About 3.2% of the eggs are lost during incubation. Average hatchability of all eggs, including those deserted because of wildfire, inundation by water, or

Table 1. Difference in numbers of Tanchos censused by the Hokkaido Educational Committee between 2 successive years.

Year	Number of tanchos			Minimum census error ^a
	Adult	Juvenile	Total	
1966	139	26	165	-6
1967	171	34	195	
1968	141	21	162	-17
1969	179	20	199	
1971	111	17	128	-49
1972	177	26	203	
1976	164	37	201	-11
1977	212	22	234	
1978	174	18	192	-23
1979	215	34	249	

^aDifference between total count in the year of reference and the total count of adults the next year.

interference by man, was 66.7% (52.9 to 91.7%) of 75 eggs. Among 43 nests, 74.4% had 1 or more eggs hatch. Both eggs hatched in 57.1% of 42 two-egg clutches, and only 1 of the eggs hatched in 16.7% of the nests.

Twenty percent of 25 chicks died within 10 days after hatching. The causes of their deaths are rarely known in the field, but the vicious mutual pecking between the newly hatched chicks (fratricide) may be 1 of the mortality causes in broods that contain 2 chicks.

The percentage of juveniles in the population varies from year to year (Fig. 3) and might have reached its maximum value during the most rapid growth of the population. The percentage of juveniles surviving to the age of 3 months (when they fledge) was surveyed from 1969 to 1971 in small sample populations. The percent surviving was only 46 in 1969, a year when juveniles made up 10.1% of the population in December (Table 2).

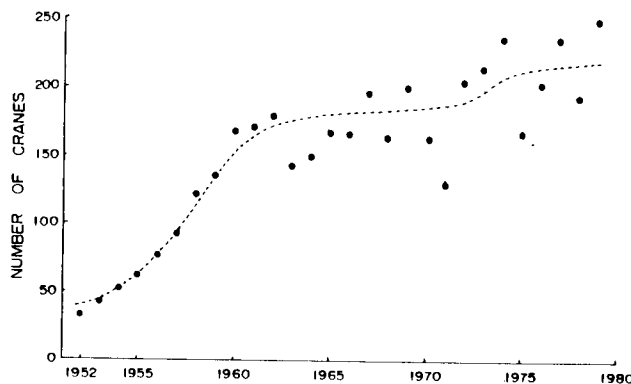


Fig. 2. Growth pattern of wild Tancho population in Hokkaido, 1952-1980.

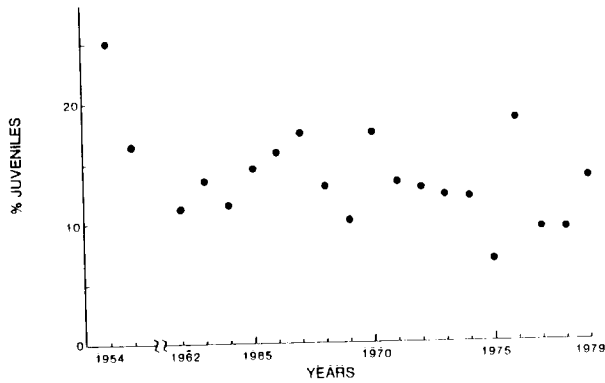


Fig. 3. Percentage of juveniles in the wild population of red-crowned cranes in Hokkaido.

Juvenile mortality is presumed to be lower during winter than in fall and to total 10 to 20% from the end of August to the end of the following March. The numbers of juveniles found dead in the field have been about equal to the numbers of adults found (1969-1973, about 52 juveniles per 100 deaths (range 41 to 69), but obviously the juvenile mortality is much higher. About the same numbers of juveniles and adults are killed by collisions with power lines.

Although these natality and mortality data are drawn from a small number of samples, they correspond with the average percent of juveniles (6.8 to 18.4, average 12.9) noted during the December census. I do not know if these reproductive values, collected al-

most a decade ago, are characteristic of recent breeding of Tanchos, but there is little difference between the average percentage of juveniles in the population during 1962-1970 and during 1971-1979. Note, however, that the 3 lowest rates (under 10%) occurred only in the last 5 years. Therefore, it is necessary to collect up-to-date reproductive data to assure protection of this unique nonmigratory population.

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Table 2. Survival of juveniles to fledging, Hokkaido Japan, 1969-1971.

Year	Chicks hatched	Juveniles at age 3 months	% survival rate	Juveniles counted early December	% juveniles in flocks
1969	11	5	46	20	10.1
1970	10	7	70	28	17.4
1971	4	2	50	17	13.3

BREEDING HABITS OF RED-CROWNED CRANES

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The red-crowned crane (*Grus japonensis*) is 1 of China's magnificent birds. Studies of its breeding habits were accomplished during 1974-1978 at the Jalong Natural Reserve in the lower reaches of the Wu Yu-erh River, southeast of Chichihar, Heilongkiang Province. Additional observations were made in different districts of the San-jiang and Sung-nun Plains. Twenty clutches were discovered and systematic studies were made of 2 clutches.

DISTRIBUTION AND POPULATION DENSITY

The breeding range of red-crowned cranes in China is from the middle and lower streams of Nun-jiang to the Ussuri Valley (Fig. 1). During the nesting season the population density of cranes is greatest in the reed swamps (1.2-1.5 cranes seen per hour, Table 1). These areas are mainly located in the lower reaches of the Wu Yu-erh, Holin, and Du-lu Rivers, and the Qi-xing River Basin. These swamps provide the red-crowned cranes with ideal nesting habitat. In other swamps (*Carex* in particular) the number of cranes seen is comparatively small (0.40 per hour) and in the meadow bogs the number is the lowest (0.07 per hour).

In the meadows and *Carex* swamps most of the cranes are nonbreeders.

In 1975 and 1978 investigations were carried out using the quadrat and the belt transect methods. The data indicate that the population of red-crowned cranes in the above-mentioned breeding range was over 1,000 birds.

ACTIVITIES BEFORE NEST BUILDING

Red-crowned cranes migrate to the breeding range in family groups in early or mid-March. In the Jalong Natural Reserve I noted that cranes first appeared on 8 March 1975, 10 March 1976, and 18 March 1977. At that time the 1st signs of thawing of the lower reaches of the Wu Yu-erh River were seen. The average temperature during the day was below 0°C with occasional snowfalls. The silence of this vast empty swamp was broken by the arrival of the cranes, 1 of the earliest birds to migrate to this area. They came flying either in a straight line or in V-formation, often uttering low calls sounding like "Ko-lo-lon, ko-lo-lon..."

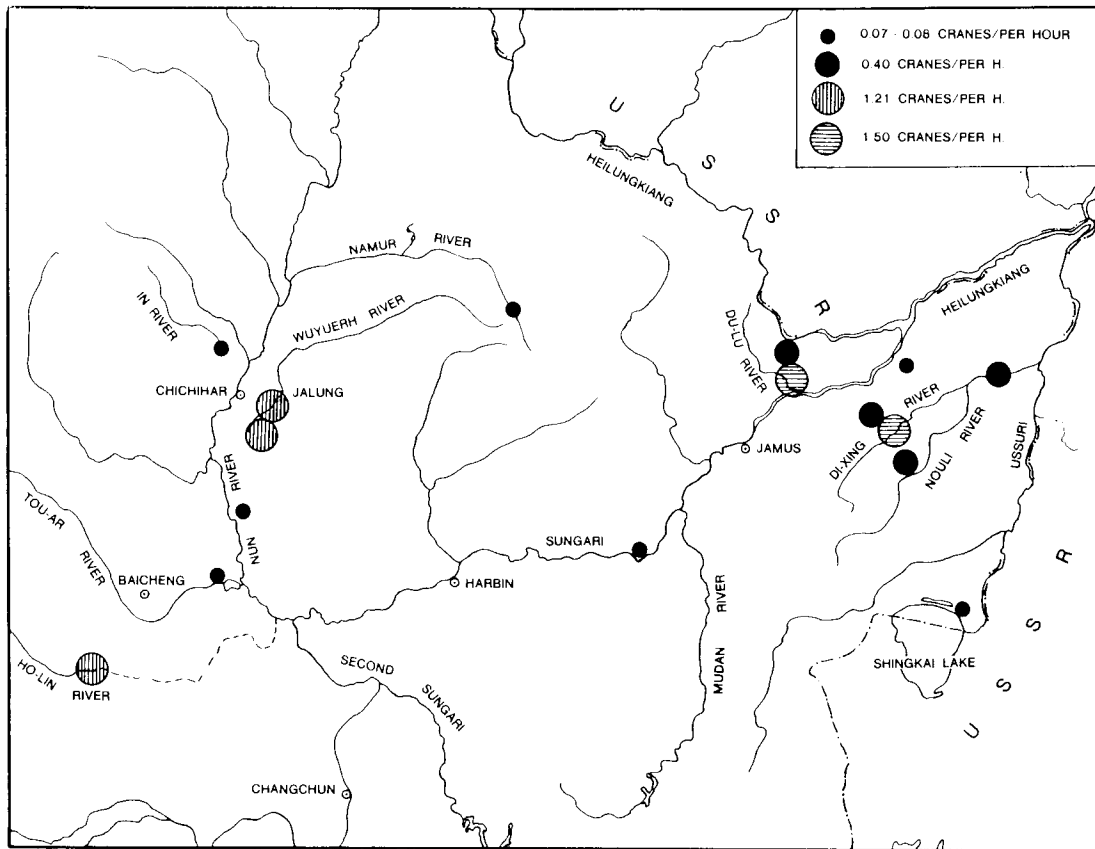


Fig. 1. Distribution of red-crowned cranes during breeding period.

Table 1. Relative population density of red-crowned cranes in 3 habitats in China.

Habitat	Sung-nun Plains			San-jiang Plains		
	Hours afield	Cranes observed	Cranes observed per hour	Hours afield	Cranes observed	Cranes observed per hour
Reed swamp	186	225	1.21	55	82	1.50
Carex swamp				32	14	0.40
Meadow	97	8	0.08	28	2	0.07
Total	283	233	0.82	115	98	0.85

The parent birds choose their nest location soon after arrival at the breeding range. The parent birds simultaneously begin to drive away the postjuveniles that had been living with them and had followed them to this nesting habitat. The male parent usually chases the postjuvenile birds; sometimes the female helps. The parents are very fierce when they drive away their young. During 1 of my observations, I saw a parent chase its young flying 20 m overhead pecking at the postjuvenile with its beak and even clawing feathers from the young. Usually a parent chases the young about 1.6 km away from their nesting ground but soon the young birds return. It was often necessary for the parents to chase their young repeatedly before succeeding. After permanently leaving their parents the abandoned young may move about individually or assemble with other yearlings in a temporary flock of 2 to 6 birds. Their behavior usually lacks any regular pattern.

Copulation usually occurs from sometime between sunrise and 0800 hours or after 1500 hours in the afternoon. Before copulation, the male usually makes arching and stretching movements of his neck. He flaps his wings and jumps up and down. Sometimes the female makes similar movements in response. Then the female bends her legs, half spreading her wings, with her neck stretched forward. The male then spreads his wings, mounts onto the back of his mate, and copulates. During copulation, low calls sounding like "Kololo..." are often heard. Copulation continues for about 10 seconds and then the male slides forward down over his mate's head. The male then flaps his wings several times and makes dancing movements. A pair of birds was once observed copulating 3 times in 40 minutes.

During the mating interludes the pair often stand together, necks stretched vertically, with their bills



Fig. 2. Red-crowned crane nest.

pointing to the blue skies. They often exchange high sonorous calls, sounding like "Koo-koo..." or "Koko-koko..." These sounds, made by 1 bird and answered by the other, are pleasing to the ear. Crane calls are frequently heard from about sunrise until about 0800 and after 1500 hours. Calls of cranes can also be heard during the night for a distance of more than 2 km.

NESTS AND NEST-BUILDING

Nest-building begins as early as the end of March; both parents participate. Most nests are built in the shallow waters of the reed swamps or on the damp marshlands. Nests are rarely constructed in other kinds of marshes or meadow bogs. The cranes are very secretive during nest-building. They seldom utter calls and if they have been alarmed they leave their unfinished nest to build a new 1 elsewhere.

When the nests are being built, the ice has not yet thawed so the nests are built on the ice. After the ice had melted I found that 16 of the 20 nests were in water 5-25 cm deep, and 1 nest was in water 30 cm deep. The other 3 nests were built on damp marshland borders.

Most of the nests were well hidden. Ten nests were hidden by high reeds and grass which nearly surrounded them, 8 were partially surrounded and fairly well hidden by reeds and grass, and only 2 nests were without anything to conceal them. The nest is a simple affair in the shape of a shallow dish (Fig. 2). It occupies a large area with a slight concave hollow in the center where the egg is laid. There is nothing lining the nest.

The nest material is whatever is nearby, mainly the stems, leaves, and inflorescence of the Graminae and Cyperaceae plants, e.g., *Phragmites communis*, *Deyeuxia angustifolia*, carex, and cyperus. Roots of plants were seldom used; this is a striking contrast to the materials used by *G. vipio* building nests in the same environment. The analysis of 20 nests showed that 13 (65%) were 90% reeds. One nest was about 10% reeds. The percentage of different materials used for nest-building depends solely on the kind of plants found nearby.

The size and structure of nests depends on the depth of nearby water and the kind of building material available. Nests built near rather deep waters are big and fine and close in texture; nests where weeds are dominant are also quite fine and close in texture. Generally nests built of reeds are crude in structure, thin, and small in size with holes between

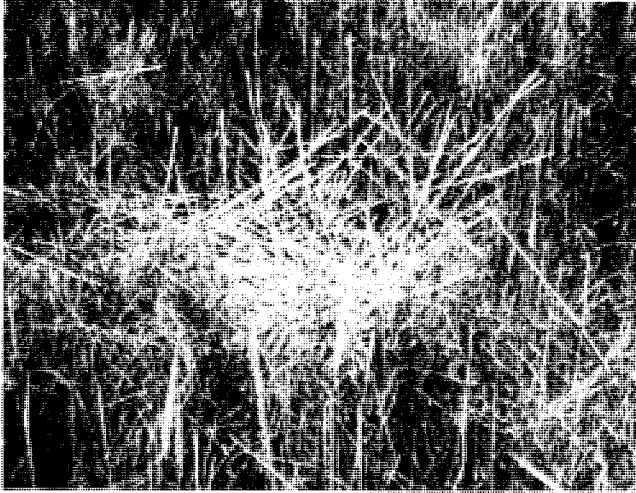


Fig. 3. A nest-like structure near a nest.

the materials; looking down into the nests an observer can see mud through the holes.

Measurement of the red-crowned crane nests resulted in the following:

	Average (range)
Outer nest edge (dia.)	135(110-200) × 165(115-220) cm
Inner nest bowl (dia.)	48(30-70) × 52(30-80) cm
Nest bowl depth	6(4-7) cm
Nest height	25(10-38) cm

The nest becomes the center of an open space because reeds and grass are cut or plucked by the pair for nest-building and the vicinity is often used by the cranes for other activities. The diameter of the open space is 4(3×8) × 5.4(3-10) m. The parent birds often go to and from their nest; consequently, many paths radiate from it. Generally there are 3 to 8 paths. Some of the paths also have many branches. Frequently used paths are wider than the others.

During the investigation, I found other nest-like structures made of dried reeds (Fig. 3) near 3 nests. Four of these nest-like structures were near 1 of the nests, 2 were near the other 2 nests. They averaged 60 × 75 cm in diameter; their distance from the nests was 3 to 5 m. The nest-like structures were built near paths often used by parents. During incubation, before and after nightfall, the crane not on the nest often went to a nest-like structure. A parent has also been seen coming out of these nest-structures before and after sunrise. These structures are built by parents and are used to rest in during the night. During the period of parental care, similar nest-like structures were also found in the vicinity where the family was active.

The shortest distance between nests was 800 to 1,000 m. One nest was 500 m from the bank of a dike and another 500 m from farmlands.

EGG-LAYING AND INCUBATION

Egg-laying begins in April and ends in late May. There is only 1 clutch per year. Among the 20 clut-



Fig. 4. A red-crowned crane egg with irregular specks.

ches discovered, 13 contained 2 eggs each, 1 clutch had 3 eggs, and 4 clutches had 1 egg each (the latter clutches may have been incomplete). Two nests contained no eggs when examined.

The egg shell is greyish-white with a light pink cast, and sprinkled with purple, dark brown, and brown irregular specks. The newly laid egg is lustrous (Fig. 4). Sixteen eggs averaged 239.4 g and 68.8 (66-71) × 105.3 (97-111) mm. In 1976 we found a crane egg which, except for a very few dark brown specks, was completely white (Fig. 5). It weighed 183.3 g and measured 59.5 × 92 mm.

Incubation is shared by both parents (Table 2). The shortest time interval each parent incubated was 59 minutes and longest time 650 minutes. The average incubation time was 70 minutes and then the parent stands up to air the eggs. The shortest time between airing of the eggs was 35 minutes and the longest 77 minutes. The average time of each airing was 3.8 minutes. The shortest time was 1 minute and the longest 11 minutes. Observations of 1 nest indicated

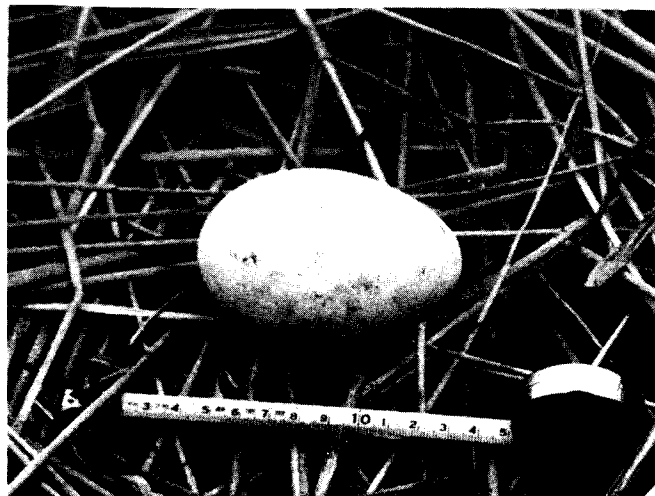


Fig. 5. A red-crowned crane egg without specks.

Table 2. Activities of red-crowned crane parents during incubation, Jalong Nature Preserve, China.

Activity	Nest II 03 ^a		Nest I 06			
	26 April early incubation period	8 May mid- incubation period	19 May mid- incubation period	21 May mid- incubation period	25 May mid- incubation period	29 May final incubation period
Times parents exchanged incubation duties	4	3	2	4	2	1
Minutes parents incubated	919	925	805	597	730	925
Times eggs were aired	12	16	14	17	11	14
Minutes both parents left the nest	11	5	125	333	200	5

^aEach column represents an observation period of 930 minutes, from 0400 hours (before sunrise) to 1930 hours (after sundown).

that incubation takes 31 days. Twenty-seven chicks hatched from 14 nests that contained 29 eggs.

The parents are inactive during incubation and seldom search for food. They are ferocious in temperament and vigilant. The parent outside the nest keeps a close watch for other cranes entering its territory. It immediately chases any intruder away. The species chased away included *Grus vipio*, *Circus melanoleucos* flying over the nest, and sometimes *Amas poecilorhycha* that was building its nest in the same territory. But the *Amas poecilorhycha* was chased only a short distance. Other birds building nests near the red-crowned crane are *Fulica atra*, *Ardea purpurea* (5 nests 80 m from a crane nest), and *Botaurus stellaris* (only 3 m from a crane nest).

Observations of the pair at Nest II 03 for 4 days indicated that the parents generally found their food and chased away other birds within 600 m of the nest. The farthest distance that a parent searched for food

was 1,200 m from the nest. The greatest distance a parent chased other birds was also 1,200 m from the nest (Fig. 6). The breeding territory contained 130 ha.

Unlike the pair at Nest II 03, the parents at Nest I 06 reacted little to birds entering their breeding territory regardless if they were of the same or other species. Sometimes a parent at Nest I 06 even sought food together with other red-crowned cranes only 20-50 m from its nest. The parents also showed no antagonism towards birds infringing on their breeding territory. Activities of the pair at Nest I 06 all took place within 500 m of the nest. The breeding territory contained 45 ha.

YOUNG BIRDS AND PARENTAL CARE

The earliest hatching occurs during the 1st 10 days of May. A few days before hatching, short, weak "shi-shi" cries of the chicks can be heard. This is

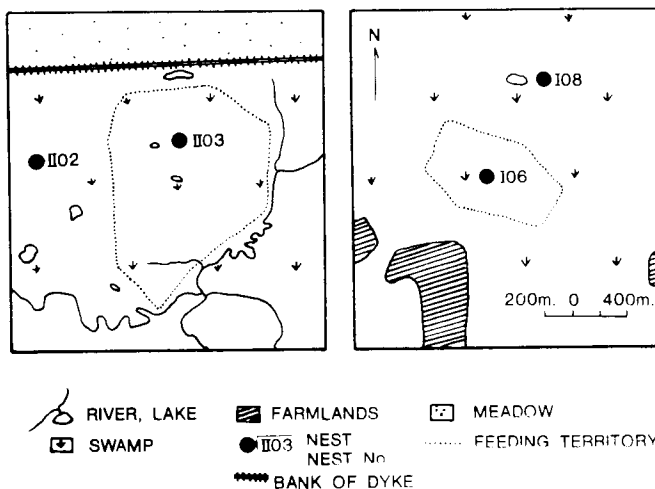


Fig. 6. Sphere of activity of parent birds during egg-laying.



Fig. 7. Small chick pipping its way out of the shell. One wing is visible.



Fig. 8. Red-crowned chick in the weeds.

followed by the pipping of a 0.05-cm-diameter hole on the blunt end of the egg. This hole increases in size as the chick bores its way from the egg (Fig. 7).

The 2nd egg in the clutch generally pips the 2nd day after the 1st chick emerges. After the chick leaves the egg, a parent crushes the shell and throws it from the nest. Only a small percentage of shell is left in the nest. Before the chicks leave the nest, the parents keep watch over them continually. As a result the reeds and grasses around the nest are all trodden into the water by the parents.

The chicks (colts) are downy, yellowish-brown, but pale below; the bill is cream-yellow, and the tarsus

drab. The 1st day the chicks leave the nest they follow their parents to about 20 m from the nest. On the 2nd day the family extends the activity range to about 100 m from the nest (Fig. 8). As the chicks grow the activity range of the family progressively expands. Throughout chick-rearing both parents closely watch the young.

The young develop very quickly. By mid-July the chick's height is 1 m, the down has already disappeared, the neck and head is yellowish-brown, the feathers of the body are mottled yellowish-white, and the secondaries and tertiaries are dark brown. By August the colts begin to follow their parent birds in flight. By early and mid-September the young are able to fly a considerable distance with their parents. By this time most cranes move to nearby hills. Sometimes they go to croplands to eat corn. Their height is slightly less than the parents. A large part of the feathers of some of the young is white.

They generally start migration in early or mid-October. All birds have usually left the breeding range by mid-November. Thus they stay in the breeding range about 240 days. The young cranes migrate south with their parents in family groups. First they circle in the air, flying higher and higher. Sometimes the parent birds utter low and even calls, sounding "kololo-kololon..." and off and on the young birds also make weak thin calls, sounding "shi-shi-shi-shi..." The parents lead the way with the rest of the family following in a straight line or in V-formation. They move their wings slowly, flying gracefully, freely and in their full beauty, and gradually disappear from sight.

Before migrating south the young average 1,245 (1,180-1,400) mm body length, 141.4 (137-153) mm culmen length, 584 (540-610) mm wing length, 238.5 (213-260) mm tail length, and 261 (250-280) mm tarsal length.

THE ANNUAL CYCLE OF RED-CROWNED CRANE

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The red-crowned crane (*Grus japonensis*) is 1 of the typical migratory birds of China. Its annual cycle may be divided into breeding, migrating, and wintering phases. The breeding phase lasts from March to September of about 1/2 of the year. They migrate to Heilongjiang Province in early March when snow and ice are still present, look for a suitable place to nest, and begin to construct nests by the end of March, laying eggs in the 1st 10 days of April. There are usually 2 eggs. Both parents take turns incubating the eggs. Incubation requires about 31 days. The chicks fledge in 3 months. By late August to early September, the juveniles have attained the size of adults.

The migration phase has 2 categories--spring and fall. The duration of the spring migration is about 1 month. Generally, the cranes leave their wintering area (Anhui or Jiangsu) between late January and the

end of February. Most cranes reach Heilongjiang between the last 10 days of March and the 1st 10 days of April. Fall migration begins in late September and generally is completed by late October. In Jalong Waterfowl Reserve the last birds were seen 29 October 1978 and 26 October 1979. In especially warm years some birds may stay until early November. The cranes arrive at Anhui from late October to mid November.

The cranes are on the wintering grounds from November to January, about 3 months. Under natural conditions they migrate south for winter but when domesticated they can live outdoors at a temperature of -30°C and breed normally the next spring, e.g., in the Jalong Waterfowl Reserve (1978) and in Harbin Zoo (1973-1979). Figure 1 shows the relationships between crane activities and the environmental changes.

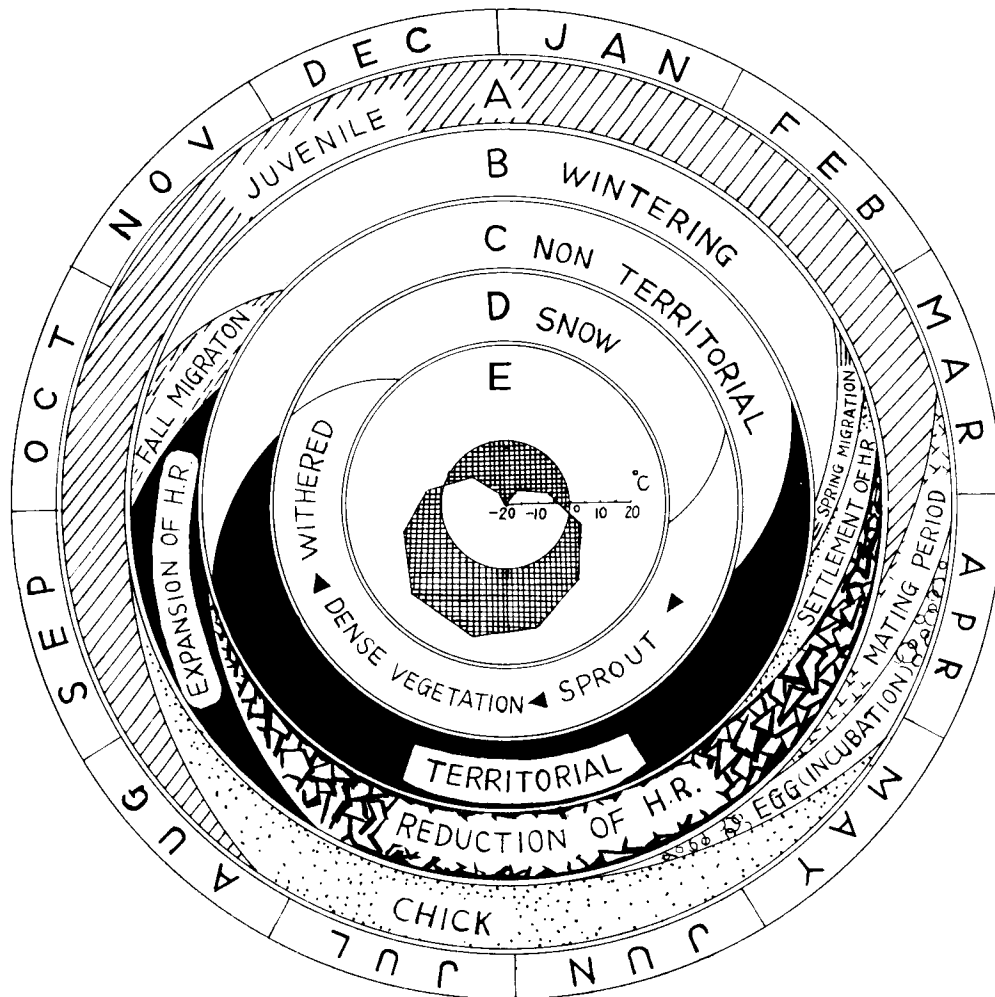


Fig. 1. Relationships between red-crowned crane activities and environmental conditions. A = development of young, B = change of activity range, C = social pattern, D = environmental change, and E = average monthly temperatures. Figure adapted from Masatomi and Kitagawa (1974).

The annual cycles of the cranes in northeastern China and those in Hokkaido, Japan, differ in 2 respects. The breeding phase in Hokkaido begins 1 month later and autumn migration is completed 1 month earlier in the Hokkaido population. Both populations migrate south for winter.

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RED-CROWNED CRANE IN NEMURO DISTRICT

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The total population of red-crowned cranes (*Grus japonensis*) inhabiting eastern Hokkaido is approximated by the census carried out early each December. There were 271, the most ever seen, in 1979. They usually winter in restricted areas around the artificial feeding stations in Kushiro District and begin dispersing widely in pairs or small flocks over the marshes selecting their nesting sites in February and March. Some pairs secure breeding territories in Kushiro Marsh and neighboring small marshes along several rivers in Kushiro District; others move to Nemuro and Tokachi Districts, especially to the former in mid-March.

In Nemuro District, 4 or 5 nests were located in Nemuro Peninsula, 3 in Notsuke Peninsula, and about 20 around Lake Furen which was the main nesting grounds in the district. Nesting sites of cranes in Nemuro District confirmed to date, but not always in the same spot every year, are illustrated in Fig. 1.

When beginning their nesting activities the parents

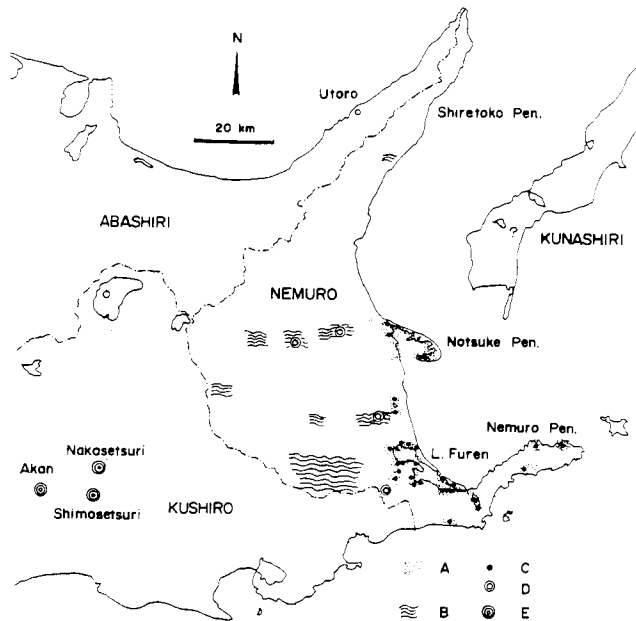


Fig. 1. Distribution of *G. japonensis* in Nemuro District, eastern Hokkaido. (A = nesting habitat, B = place of temporary residence during fall migration, C = nesting site, D = small winter feeding station in Nemuro District, E = large winter feeding station in Kushiro District.)

drive their previous year's young from the territories. Such subadult nonbreeders eventually form small flocks and some of them remain for awhile near the winter feeding stations but eventually disappear until the end of April. The wandering areas of these nonbreeders were unknown for a long time, but in 1973 it was confirmed that most of them assemble at the mouth of the Furen River (Inoue 1975). The Furen River area abounds in many kinds of tiny creatures, e.g., molluscs, lugworms, and fish (Ikeda et al. 1975) which cranes eat. The area is unsuitable for nesting activities of cranes because of the large rise and fall of the tide.

More than 30 nonbreeders occur in the Furen River area. There are many opportunities to watch them during May and July, but after that they begin to disperse widely. They move to Shiretoko Peninsula and probably even to the South Kuril Islands. For example, 2 subadults were observed at Utoro, Shiretoko Peninsula, in May 1979 (Nakagawa 1979). I hope special measures will be taken to protect the area surrounding the mouth of the Furen River because the area appears to be incredibly important for maintaining the nonmigratory population of *Grus japonensis*.

From autumn to early winter the cranes gradually move to the wintering ground in Kushiro District. Family groups, pairs unsuccessful in nesting, and nonbreeders may depart at different times, use different routes in migration, and rest at separate areas during migration, but the precise information is unknown.

Unless it becomes possible to identify each individual crane, we will be unable to fully understand their behavior. Thus, it seems that a good conservation plan for cranes cannot be established until studies are made of individually marked cranes. A special concern is that the nonbreeders recently seem to exhibit less tendency to gather at the mouth of the Furen River, so it is urgent that we learn the factors causing this possible change in behavior.

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ARTIFICIAL INCUBATION AND REARING OF RED-CROWNED CRANE IN KUSHIRO CRANE PARK

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A netted enclosure of about 10 ha, entitled Red-crested Crane's Natural Park (Kushiro Crane Park), was constructed for breeding *Grus japonensis* at Otanoshike, Kushiro, in 1958. Five male wild cranes were captured and released initially (1 died soon after) but 22 individuals were present by 1980 (Table 1).

ARTIFICIAL INCUBATION

Cranes usually start to construct their nests on the snow-covered marsh at the end of March. Egg laying generally begins in April (the earliest record is 20 March 1967) and ends in late May. Such heavy snowstorms have occurred in this season that the nests were covered with snow (45 cm on 17 April 1979) and later immersed in snowmelt. Therefore the natural hatching rate has been very low, 37% from 1962 to 1979. Since 1968 eggs have been artificially incubated.

Two types of eggs are distinguished by color of the shell; 1 is almost white without any speckling. The 2nd is greyish-white, sprinkled with purple, dark-brown, and brown specks that are irregular in size and shape. Fresh eggs are generally 6 to 6.5 by 10 to 11 cm and 230 to 250 g.

Table 1. Red-crowned cranes kept and eggs laid in the Kushiro Crane Park, Japan, 1958-1979.

Year	Cranes	Breeding pairs	Eggs
1958	4	0	0
1959	4	0	0
1960	5	1	0
1961	5	1	0
1962	6	2	1
1963	6	2	1
1964	6	2	3
1965	6	2	2
1966	5	2	3
1967	5	2	1
1968	9	3	10
1969	13	3	10
1970	18	3	12
1971	19	3	11
1972	19	3	11
1973	20	2	12
1974	19	2	8
1975	18	2	10
1976	19	5	8
1977	23	5	19
1978	24	5	19
1979	22	5	18

The incubator used in our park is the K-type of Showa Furanki Company. Refinement of air temperature and humidity control should greatly improve the hatchability of eggs. The air temperature was set at 38.5°C near the upper surface of eggs which were left horizontal in the incubator. By controlling the width of the funnel we attempted to limit deviation of the air temperature to less than $\pm 2^\circ\text{C}$ between the upper and lower egg surface. The relative humidity was measured with a hygrometer and controlled at about 50%. Eggs were turned 120° along their long axis every 4 hours.

Chicks usually hatched after 32 days. When the chick's bill appeared from the small hole pipped in the shell, we decided the angle of the egg should be rotated by judging the chick's call (comfortable call, piruru...; uncomfortable call, pi- or bi-) and it was often about 180°. We could hear some chick calls through a stethoscope about 5 days before hatching. Sometimes a small amount of warm water was instilled into the shell to aid hatching.

There were no clear external differences in appearance of normal and abnormal eggs. We distinguished them by the condition of the air chamber (Fig. 1). The hatching rate of artificially incubated eggs and the status of these chicks are shown in Table 2. The hatching rate of 82 artificially incubated eggs was 40.2% (1968-1979).

REARING CHICKS

After hatching, the temperature in the incubator was kept at 35°C until the chicks excreted their first droppings. Chicks were 130 to 160 g in weight and of 10 to 15 cm height in usual standing posture. Before the first feeding, chicks were shown fluttering yellow or red cloth strips held by a pair of bamboo chopsticks. With this training, chicks learned to peck at food items.

A bit of food was offered to the chicks 6 hours after their first excretion. Then they were transferred to a small cage that was heated continuously. Chicks were initially fed 8 times daily. The growth curve of a chick is shown in Fig. 2. Chicks were given such foods as boiled yolk, artificial chick food, powdered insects, half boiled spinach, corn, *Oenanthe javanica*, *Stellaria neglecta*, *Misgurnus an-*

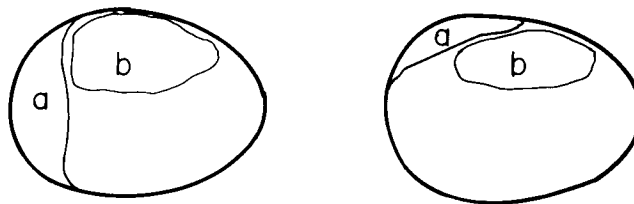


Fig. 1. Normal (right) and abnormal (left) air chamber of egg artificially incubated (a, air chamber; b, yolk).

Table 2. Artificially incubated eggs and survival of chicks of *G. japonensis* in the Kushiro Crane Park.

Year	Eggs incubated	Eggs hatched	Chicks survived >3 months
1968	4	0	0
1969	4	2	0
1970	8	5	3
1971	3	0	0
1972	7	2	1
1973	10	5	2
1974	5	3	1
1975	8	4	1
1976	4	3	3
1977	9	4	3
1978	12	3	1
1979	8	2	1
Total	82	33	16

guillicaudatus, *Moroco percunurus*, *Tribolodon ezoe*, and *Anisogammarus jezoensis*.

Chicks are able to fly about 100 days after hatching. After observing this flying we could confirm

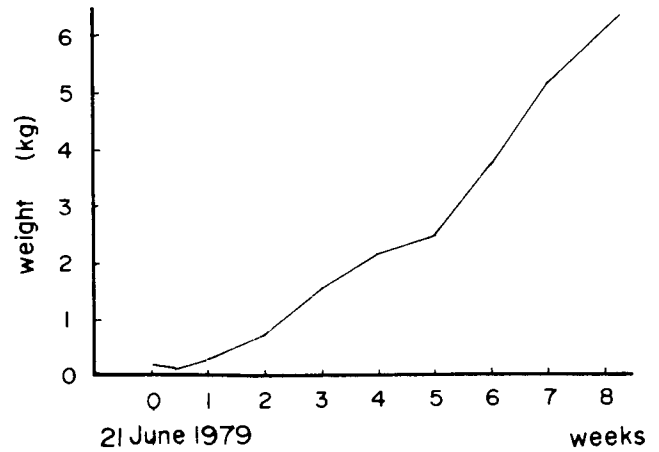


Fig. 2. Growth of a chick reared artificially.

that the young crane was reared successfully. In Kushiro Park 16 young cranes were artificially reared (1968-1979) and 11 of them are still alive (spring 1980).

Many people have helped greatly in this work; far too many to list them. We sincerely thank them all. Many thanks to our own families and we also thank Prof. emeritus Tadamichi Koga, Dr. Tetsuo Inukai, Mr. Haruo Saito, Mr. Tadashi Murakami, and Dr. Shoichiro Satsuki.

A HISTORICAL REVIEW OF CONSERVATION OF RED-CROWNED CRANE (TANCHO) IN HOKKAIDO

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Red-crowned cranes (*Grus japonensis*), called "Tancho" in Japanese, were undoubtedly common occupants of the swampy country centuries ago when Hokkaido was largely covered by deep forest, fen, and moorland, with human settlements scattered like islands in the wilderness.

TOKUGAWA ERA (1603-1867)

Murashima (1688) stated in his diary "The research ship (the Kaifu-sen) arrived at the mouth of the Ishikari River near Sapporo...and its crew bought 3 young Tanchos that were being reared by the native women (Ainu menoko). Then they transported them to the Mito Clan in Honshu." Kaibara (1708) said "Tanchos breed at Matsumae in the southern part of Hokkaido, and not in Korea and the western part of Japan." Arishima

(1717) noted that "Cranes such as white-naped (*G. vipio*), common (*G. grus*), and Tanchos were captured in Saghalien and eastern Hokkaido (at Kiritappu near Kushiro and at Tokachi around Obihiro)" (Fig. 1).

Itakura (1739) stated "There were plentiful waterfowl, such as cranes, storks, swans, geese, and ducks migrating northward in spring in Hokkaido. Some of them were found in marshy grounds of dark valleys in summer." When Itakura (1739) passed through Lake Onuma and Lake Konuma in summer, he found waterfowl abundant and also mentioned that these birds were more plentiful at Shiribetsu (along the Shiribetsu River) and Shikotsu (present Chitose).

Matsumae (1781) noted in his historical records of Matsumae Clan that several kinds of cranes were numer-

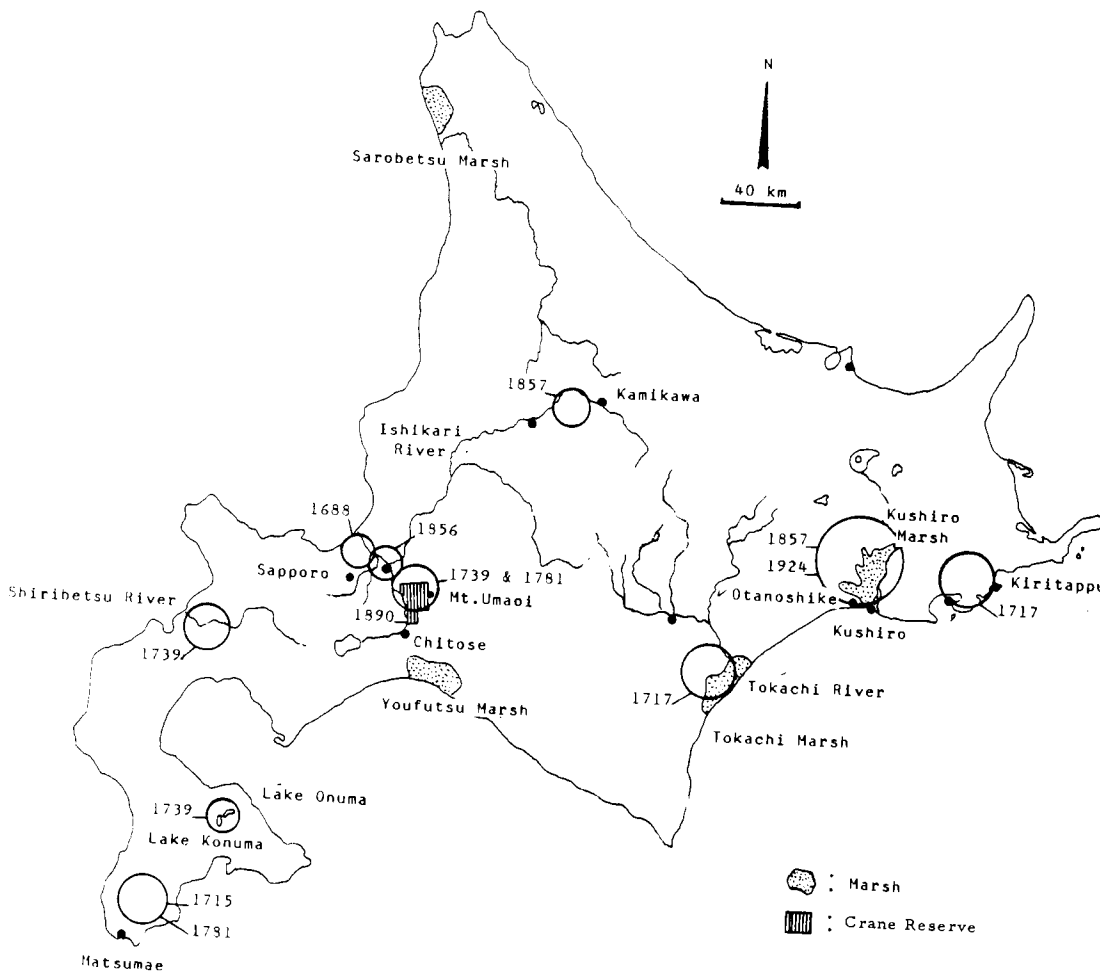


Fig. 1. Distribution of Tancho (1688-1924) on Hokkaido as described in early literature.

ous at marshlands of Shikotsu. A member of Matsumae Clan, Okada, harvested about 300 cranes from Hokkaido during his lifetime. Hiratsuchi (1784) said several kinds of cranes nest abundantly in marshes in Hokkaido. Among them, Tanchos were especially numerous. When cranes were in especially large flocks, Ainu hunters were afraid to capture them in daytime and instead caught them at night.

Some Tanchos were reared on the grounds of Samurai residences and Buddhist temples. Commoners were permitted to hunt cranes in Hokkaido, their meat was eaten, and salted cranes were shipped to Honshu. Therefore, it seems that the cranes were plentiful in those days in Hokkaido.

Matsuura (1856) stated that when he passed through Tsuishikari, Ebetsu, by ship, he saw bush warblers, wild ducks, doves, eagles, hawks, many unidentified birds, cranes, and deer in herds of 10 to 20 along the Ishikari River. I presume that these cranes were near the Ishikari River, Ebetsu, in the neighborhood of Sapporo.

Matsuura (1857) arrived at Ichinange (near present Kamikawa) on the evening of 28 May. Next day he went up to Kayano along the river and found many cranes in wide marshes, but the natives (Ainu) did not hunt the birds. Therefore, the cranes seldom flew unless they were approached closely. I suppose that there were many Tanchos in Kamikawa District at that time and it is interesting that the natives did not usually disturb the cranes.

Mori (1857) saw 2 Tanchos in the neighborhood of Otanoshike on the way from Kushiro to Shakubetsu on 28 July. Cranes were plentiful in wide marshes in Hokkaido until about the early (1863) Meiji Era (Hokkaido-Cho 1937). Most of the cranes were Tanchos and usually it was permissible to hunt cranes and sell the meat for food. Although hunting by commoners was often prohibited by the feudal rulers in Honshu, it was not strictly limited by those rulers in Hokkaido. In fact, in Honshu the shogunate (governors) and every clan established large inviolate sanctuaries called "Otomeba."

MEIJI ERA (1868-1911)

Many cranes were killed, salted, and shipped to Honshu because there were no restrictions on hunting in Hokkaido at the beginning of Meiji Era. The popu-

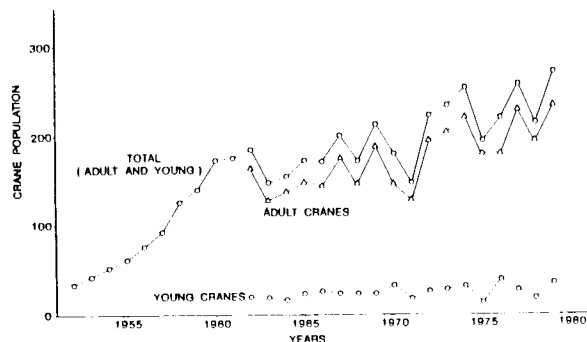


Fig. 2. Population of Tancho on Hokkaido as censused by Hokkaido Board of Education, 1952-1979.

lation of cranes had drastically decreased on Hokkaido by 1887. The first modern national game laws in Japan, made official 20 January 1873, consisted of 25 articles designed mainly to control hunting rather than to perpetuate wildlife. This law established a licensing system which recognized 2 classes of hunters: a professional who paid a fee of ¥1.00, and sporting nonprofessional hunters who were taxed ¥10.00. A hunting season was established from 1 December through 31 March.

The hunting season was lengthened from 15 October to 15 April in the 4th set of this early Law issued 23 January 1877. It then became illegal to hunt game without a license and to hunt between sunset and sunrise. This game law did not establish articles for bird protection; consequently, any species of bird could be shot until the next imperial game laws were issued on 5 October 1892. Crane killing was specifically prohibited by the Hokkaido Prefectural Government in 1889 when this bird was threatened with extirpation. The new law designated the type of punishment for offenders.

In 1890, Hokkaido Prefectural Government established preserves to protect the cranes and other birds in marshes around Osatsu, Tsurunuma, and some lakes from the foot of the Umaoi Mountains to along the Chitose and Youbari Rivers. Therefore, some cranes were evidently breeding in the marshes of Sapporo, Chitose, Youfutsu, Youbari, and Sorachi at that time.

Minor changes in licenses, fees, and provisions for protection were made in the next imperial game law proclaimed 20 March 1895. Hunters were classified into 3 groups according to the amount of income tax paid in the previous year and were charged accordingly for their licenses. Regulations were established requiring reports of all business dealings that involved protected birds, especially cranes, i.e., their rearing, buying, selling, and caging. Despite the imperial game law, and the policy of crane protection by the local government, the Tanchos gradually disappeared from Hokkaido. Kono (1899) recorded that the cranes disappeared from around the lakes of Umaoi and Osatsu, which had been designated as protected nesting areas.

TAISHO ERA (1912-1925)

At the beginning of Taisho Era one could hardly see living Tanchos except in zoological gardens. In 1924, Saito (1926) recognized that a small nonmigratory group of Tanchos managed to survive in the extensive and almost inaccessible marshes just inland of Kushiro, Hokkaido. Saito also suggested that about 20 individuals were probably alive in Kushiro District.

Walkinshaw (1973) described the more recent history of Tancho in his large book and I refer the interested reader to it for further information. The annual December census has been continued by the Hokkaido school children since 1952. The population of Tanchos in Hokkaido, as determined by the Board of Education in Hokkaido, has apparently been slowly increasing during recent years (Fig. 2).

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COUNTERMEASURES FOR THE PRESERVATION OF RED-CROWNED CRANES AT PRESENT AND IN THE FUTURE

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The Hokkaido and Japanese governments have tried for a long time to protect red-crowned cranes (*Grus japonensis*), "Tancho," since its dangerous population decline in Hokkaido in the last century. Here I would like to briefly summarize past protection measures and itemize our basic plans for preservation of cranes in the future.

PAST EVENTS

- 1889 Hunting of Tanchos was banned by the local government. They had never been protected in Hokkaido until that time.
- 1890 Swamps around the Chitose and the Yubari Rivers in central Hokkaido were protected as the nesting grounds by the local government.
- 1892 Tanchos were listed in the revised national game law as 1 of the protected birds.
- 1895 The Japanese government prohibited sale of cranes and collection of their eggs.
- 1919 Preservers were appointed in every prefecture.
- 1925 Hunting was prohibited in part of Kushiro Marsh, where a small population of Tanchos had been found nesting in 1924.
- 1935 Tancho and their nesting grounds (about 2,700 ha) in the Kushiro Marsh were designated as a natural monument.
- 1952 Breeding grounds and Tanchos in Kushiro were named as a special natural monument. Census of the wild Tanchos in early winter was accomplished for the 1st time (Table 1).
- 1954 The Hokkaido government subsidized the local government to supply food to the cranes during winter and to survey their habitat (Table 2).
- 1955 The central government of Japan also paid some subsidy for the cranes.
- 1967 Wherever Tanchos lived in Japan they were designated as 1 of the special natural monuments.

Table 1. Population of Tanchos in Hokkaido.

Census date	Number
29 November 1952	33
3 December 1956	76
5 December 1961	176
1 December 1966	170
4 December 1971	147
6 December 1976	220
6 December 1977	257
5 December 1979	271

Table 2. Government grants for Tanchos, 1954-1979.

Category	U.S. dollars
Feeding	\$162,869 ^a (1954-1979)
Special surveys	75,410 (1972-1979)
Facilities for protection and breeding	603,852 (1968-1979)
Total	\$842,131

^a\$1 = 244 yen.

1972-1974 The Hokkaido Board of Education made special studies of the nesting grounds of Tanchos, conducting an aerial survey.

FUTURE OBJECTIVES

The Board of Education encourages a basic ecological study of Tanchos to confirm the location of their nesting grounds, evaluate their breeding activities, evaluate their use of habitats, and learn to artificially increase their population. The causes of mortality must be detected and guarded against; thus, it is necessary that an organization be set up to study the causes of mortality (Table 3). Artificial feeding should be continued, as appropriate, while carefully considering how to maintain the cranes' natural wildness.

The swampy areas downstream in the Furen River basin, where subadult cranes usually spend the nesting season in groups until they become sexually mature, should be preserved. Habitat conditions of the river-mouth should be surveyed. Conservation education about Tanchos should be promoted. Tanchos and their habitats should be under better management to ensure that this great species will survive.

Table 3. Causes of mortality of red-crowned cranes (1950-1979).

Causes	Number
Collision with electric wires	131
Shooting	5
Injury	38
Disease	19
Uncertain	52

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