Proceedings of the 1983 International Crane Workshop

Edited by
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MESSAGE
FROM INDIRA GANDHI

Early Indian literature has many stories and legends about birds and their relationship with human beings. The Crane in particular has figured prominently in our folklore. Now it has become an endangered species. The future of our animal and bird life is linked with specific steps to preserve them as also to safeguard the eco-systems in which they flourish.

Bharatpur is known all over the world for its bird sanctuary and it is appropriate that an International Workshop on Cranes should be held there. My good wishes for its success.

Indira Gandhi

DEDICATION

Dr. Ronald T. Sauey (1948-1987) was a co-founder and a director of the International Crane Foundation. Active in crane research and conservation since 1972, Ron passed away January 7, 1987 after suffering a cerebral hemorrhage on Christmas Day. He will always be remembered for his comprehensive studies of the Siberian Cranes in India, which are eloquently presented in his 1985 Ph.D. thesis, *The Range, Status, and Winter Ecology of the Siberian Crane, Grus leucogeranus*, which he received from Cornell University, Ithaca, New York. Ron was loved and respected by many. His untimely death leaves a void that impacts on the hearts of his many friends worldwide, and the advance of the study and preservation of cranes.

DISCOVERY

If one word could sum up the essence of the 1983 International Crane Workshop at Keoladeo National Park, India, that word would be DISCOVERY.

For most of the 92 foreign delegates it was a personal discovery of an enchanting country, India, and one of earth's greatest water-bird sanctuaries, the Keoladeo National Park at Bharatpur. For all of the participants it was the discovery of kindred spirits from other nations who share a common interest in cranes. The Chinese met their Soviet colleagues, the Pakistanis, the Indians, and the Iranians had a happy reunion with their friends from the USA.

The oral presentations were peppered with discoveries. The Chinese finally located the wintering grounds of the eastern flock of Siberian Cranes and they introduced the now famous Poyang Lake Nature Reserve to the international community. Americans had discovered means of tracking cranes using radio-telemetry devices attached to leg bands, a procedure that will certainly enhance the possibilities for international cooperation in monitoring the long-distance migrations of cranes. Everyone was saddened by the discovery that Thailand has lost its cranes but encouraged that techniques are being developed to use captive-produced cranes for reintroduction into the wild.

And after a four year wait, you, the reader, have now discovered that the Proceedings of the International Crane Workshop is finally completed!

ACKNOWLEDGEMENTS

Were it not for a generous gift from the Indian Government and the United States Fish and Wildlife Service through the auspices of its excess currency (PL480) program, the International Crane Workshop would not have been possible. This support provided salaries for the in-India organizers, air tickets for participants from the USA, on-site coverage of expenses for holding the meeting at Keoladeo National Park and the publishing of this book. Memorials to Stuart Avery, former director of the International Crane Foundation, as well as a gift from the Western Foundation of Vertebrate Zoology, supported the manuscript preparation. A special expression of gratitude is extended to Mr. Samar Singh of the Indian Government and Mr. David Ferguson of the US Government.

The US Embassy and especially the Science Office provided invaluable assistance in facilitating many aspects of the communications, logistics, travel and other administrative details of the Workshop.

Scott Freeman, the coordinator for education at the International Crane Foundation, handled the necessary correspondence with crane enthusiasts worldwide and was responsible for organizing the Workshop's technical sessions. Anne Wright, of the World Wildlife Fund - India, in company with Juhi Sehgal and several other capable assistants, were invaluable in managing the myriad of details associated with hosting 187 people in a wildlife sanctuary. Pallav Das also is to be thanked for recruiting skilled interpreters for the Russian and Chinese languages.

Our hosts, the State of Rajasthan and the staff at Keoladeo National Park not only provided fine weather, unmatched birding, excellent meals and accommodations, and cultural entertainment, but they even arranged for one of the Siberian Crane families to forage in a pond within easy walking distance of the colorful tent in which the workshop convened.

Prime Minister Indira Gandhi met with the organizers of the workshop in New Delhi and extended her best wishes. Col. Sawai Brjendra Singh, the Maharajah of Bharatpur, and his family graced the workshop with their presence. The beloved father of Indian ornithology and conservation, Dr. Salim Ali, then 86, was an active participant of the entire program.

Co-sponsors of the Workshop included:

Bombay Natural History Society
Col. Sawai Brjendra Singh
Government of India
International Council for Bird Preservation
International Crane Foundation
Massachusetts Audubon Society
National Audubon Society - USA
State of Rajasthan
Tourism and Wildlife Society of India
United States Fish and Wildlife Service
World Wildlife Fund - India
World Wildlife Fund - International
World Wildlife Fund - USA
Zoological Survey of India

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RESOLUTIONS

AN INTERNATIONAL AGREEMENT ON THE CONSERVATION OF THE SIBERIAN CRANE

RECOGNIZING that the Siberian Crane (*Grus leucogeranus*) has been reduced to fewer than 300 birds and that hunting and habitat loss and disturbance have been the principal agents responsible for the decline of the species;

CONVINCED that this unique species, as well as the other species of cranes, can only be effectively protected through the concerted action of all states in which these species spend any part of their life cycle;

RECALLING existing international agreements relevant to the conservation of crane species and their habitats, including the Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979) and the Convention on the Conservation of Wetlands of International Importance (Ramsar, 1971) and existing bilateral agreements between India and the USSR, India and China, and Japan and the USSR, the International Crane Workshop, meeting at Keoladeo National Park, Bharatpur, India February 5-11, 1983

CALLS UPON the Governments of Afghanistan, India, the Islamic Republic of Iran, Pakistan, the People's Republic of China and the Union of the Soviet Socialist Republic-

(A) to become party to the Migratory Species and Wetland Conventions, if they have not already done so
(B) to implement the conventions fully
(C) to sign a special international agreement within the framework of the Bonn Convention or in some other appropriate form, on the cooperation for the long-term conservation of the Siberian Crane and

REQUESTS the International Crane Foundation and other relevant international and national expert bodies to assist these Governments in whatever way they can in elaboration and implementation of a management and recovery programme for the Siberian Crane, activities that should involve

(A) the meeting of Siberian Crane researchers from each country every second year to
(B) write and revise a Recovery Plan for the Siberian Crane which respective nations will then
(C) try to implement

RESOLUTION TO THE GOVERNMENTS OF BHUTAN, BURMA, INDIA, PEOPLE'S REPUBLIC OF CHINA & VIETNAM

RECOGNIZING that the Black-necked Crane (*Grus nigricollis*) is perhaps reduced to fewer than 500 birds throughout its range in the above mentioned nations, and

CONVINCED that this species can be saved if the cranes and their remaining habitats are protected, the 187 delegates representing 24 nations that attended the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11 1983,

RECOMMEND that all the nesting areas in India and the People's Republic of China be located and protected, and that the distribution of major wintering flocks in Bhutan, Burma, India, the People's Republic of China and Vietnam be located and the birds and their habitats protected.

IN ADDITION, as an insurance against the eventual extirpation of the species, it is recommended that captive flocks be established by transferring from the wild one egg from each nest with two eggs to breeding centers either in countries concerned or elsewhere where facilities and qualified personnel exist and are ready to assist in such an operation.

RESOLUTION TO THE GOVERNMENTS OF CHINA, JAPAN AND THE SOVIET UNION REGARDING THE CONSERVATION OF THE BREEDING HABITAT OF THE RED-CROWNED CRANE (*Grus japonensis*)

RECOGNIZING that there are two remnant populations of the Red-crowned Crane, one group of 300 birds resident in Hokkaido, Japan, and a migratory flock of about 600 cranes on the mainland, breeding predominantly into northeastern China but ranging into southeastern Siberia; and

REALIZING that China, Japan and the Soviet Union have the responsibility for the conservation of breeding habitat with each crane pair requiring several square kilometers of undisturbed shallow water habitat;

THE 187 DELEGATES FROM 24 NATIONS attending the International Crane Workshop, at Keoladeo National Park, Bharatpru, India, February 5-11, 1983, wish to complement each government for measures taken to protect a portion of the nesting habitats; but

UNDERSTANDING that the protected areas cannot support adequate populations of this graceful space demanding bird, the delegates wish to propose the following efforts be made to better assure the survival of these treasured cranes:

(A) Systematic monitoring of the nesting locations and threats on the habitat must be continually undertaken to follow the interaction between the crane and human population with the welfare of the cranes in mind.

(B) Although two of the four major breeding areas are protected in the Soviet Union (the east bank of Lake Khanka and the Khingan Sanctuary in Aikhara region), the increasing human populations and expanded agriculture in neighboring areas respectively threatens the cranes and their habitats, and it is recommended that the Soviet Union restrict agriculture and human settlements near the crane sanctuaries.

C) Of the two known major nesting areas in China, Zha Long and Yiang Hai, the Zha Long marsh is protected and the Yiang Hai area is not protected. Within the latter area, it is recommended that the central government and the local government designate the Dong Reng Gang in Fu Jin County and the source of the Duruer River in Luo Bei County and other suitable areas as sanctuaries to prohibit land development.

D) The marshlands bordering Lake Furen, Japan are of primary importance as nesting habitat for the cranes in Hokkaido and the lake is protected as a Wildlife Protection Area. However, agricultural encroachment around the lake threatens the survival of the marshes. It must be emphasized that the marshes as well as the lake surface be included in the Wildlife Protection Area. The City of Nemuro near Lake Furen is seriously planning to protect the marshes around the lake as bird sanctuaries. The workshop delegates commend the intentions of the City of Nemuro and we encourage the continuation of the constructive plan to thus aid the welfare of the Red-crowned Crane.

RESOLUTION ON THE CONSERVATION OF CRANES IN THE KAGOSHIMA PREFECTURE, JAPAN

NOTING that the crane wintering area in Izumi, Kagoshima Prefecture, Japan, has been designated as a Special Monument, equivalent to a National Treasure, by the Government of Japan,

ESPECIALLY NOTING that nearly half the world species of cranes have been recorded in Izumi, and that it holds nearly the entire world population of Hooded Cranes,

THE 187 DELEGATES FROM 24 NATIONS attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11 hereby believe that such an important place as Izumi should be recognized as one of the world's natural heritage treasures,

BUT NOTING, with deep concern, the conservation crisis resulting from using the land for *farming* that is vital to *cranes* for roosting and feeding during the winter,

IT IS RESOLVED that the Cultural Agency of the Government of Japan should establish as soon as possible a *National Crane Sanctuary* by purchasing the necessary land in Izumi for the purpose of protecting and managing it for wintering cranes and other migrating birds.

RESOLUTION ON THE PROTECTION OF MIGRATING CRANES IN PAKISTAN

RECOGNIZING the importance of the Indus River Valley as the principal flyway for the Demoiselle (*Anthropoides virgo*) and Common Cranes (*Grus grus*), and

COGNIZANT of the critically endangered status of the remnant Siberian Cranes (*Grus leucogeranus*), which migrate into the Indian subcontinent, and

AWARE of the growing incidence of live crane catching in Pakistan and perhaps Afghanistan, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983, hereby resolve to:

(A) URGE the inclusion of the Siberian Crane as a totally protected species in the laws of all countries to and through which it migrates, and

(B) ENCOURAGE the development of education programs designed to alert hunters and others of the threats posed by the hunting to and the continued existence of Siberian and other crane species, and

(C) SUPPORT efforts to place bag limits on the hunting of any crane species which may directly or indirectly threaten Siberian Cranes, and

(D) DEVELOP a program to study and monitor crane migrations through utilization of wild-caught birds which are banded and released.

RESOLUTION REGARDING A WETLAND RESEARCH INSTITUTE IN INDIA

REALIZING that the wetlands of Asia are under heavy pressure from an ever-increasing human population and, at the same time, realizing the vital necessity for proper management of wetlands for both the future economy of local farmers and the survival of myriads of birds, including the endangered crane family which is dependent on such areas, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND as a top priority that a Wetland Research Institute be set up for the subcontinent.

CONSIDERING the unique situation of Keoladeo National Park at Bharatpur, listed as of international importance as a wetland under the Ramsar Convention, it is recommended that the Wetland Research Institute, under the aegis of the Government of India and the Bombay Natural History Society, be situated in Keoladeo National Park and that the present tourist complex be converted to this institute. It is further suggested that considering the small area of the park and to avoid disturbance, that tourist accommodations and the proposed educational facility be provided outside and on the periphery of the park.

RESOLUTION REGARDING SARUS AND SIBERIAN CRANES AT KEOLADEO NATIONAL PARK

REALIZING that the Sarus Crane (*Grus antigone*) and the Siberian Crane (*Grus leucogeranus*) often feed in the same jheels of Keoladeo National Park, and

OBSERVING that the Sarus Cranes frequently displace the Siberian Cranes from their feeding area,

CONSIDERING the endangered status of the Siberian Crane and its dependence on the jheels of Keoladeo National Park, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND that an intensive study of the ecology and behavior of Sarus Cranes and Siberian Cranes be undertaken to determine how best the habitats at Keoladeo National Park might be managed to avoid competition between Sarus and Siberians for limited resources.

RESOLUTION TO THE STATE OF RAJASTHAN

In view of the importance that the natural resources of Keoladeo National Park be protected and conserved, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983, wish to recommend the following measures be considered:

(A) That the Government of Rajasthan amends various Land Allotment Rules with the objective of prohibiting the construction of brick kilns and other factories emitting noxious liquids or gases up to a distance of two kilometers or any other safe distance from the National Park.

(B) Until the above amendments are made, the Collector, Bharatpur, be sanctioned to ensure that no new brick kiln or other such factory be constructed in the vicinity of the park and that the existing mining leases for brick kilns in the vicinity of the park should not be renewed.

(C) That steps by taken to discontinue the flow of water wastes (that are full of chemicals) from Dalmai Dairy Industries near Bharatpur.

RESOLUTION REGARDING THE SARUS CRANES IN INDIA

REALIZING that the Sarus Crane, once so common in India, is now becoming threatened, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND the following suggestions:

(A) That the Sarus Crane be placed on Schedule 1 of the Wildlife Protection Act of 1972.

(B) Since Uttar Pradesh is the only state where the Sarus Crane is fairly common, that the Sarus Crane be proclaimed the "State Bird of Uttar Pradesh."

(C) That throughout the north-India range of the Sarus, surveys be conducted to determine areas of major importance to these cranes, and then

(D) In collaboration with State and Federal authorities efforts be made to protect prime Sarus areas.

RESOLUTION REGARDING THE CONSERVATION OF SALT LAKES NEAR CALCUTTA

REALIZING that the salt lakes and their marshland surroundings just east of Calcutta are of tremendous importance to a great diversity of bird life,

KNOWING that many of the salt lake-marshland habitats have been destroyed by urban expansion, and

AWARE that the remaining lakes and marshes are likewise now threatened by development projects,
The 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND that the salt lakes and marshes east of Calcutta be protected as a nature reserve for birds, including the migrating cranes, which used to visit the area and are expected to reappear before long.

RESOLUTION REGARDING COMMON CRANES AND DEMOISELLE CRANES WINTERING IN GUJARAT

REALIZING that the Common Cranes and Demoiselle Cranes that winter in northwest India are hunted during migration through Afghanistan and Pakistan, and that the Common Cranes may soon be used as foster parents for the rare Siberian Cranes, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983, wish to

CONGRATULATE the people of the State Gujarat for providing the excellent cultural environment which protects wildlife thus enabling large numbers of Common Cranes and Demoiselle Cranes to peacefully winter in the state, and

RECOGNIZING the importance of Kutch and Saurashtra regions of Gujarat as essential wintering grounds for these cranes, it is

RECOMMENDED that:

(A) A census of the cranes be carried out during the winter 1983-84 and subsequently in alternate winters to determine the numbers of each species, their productivity as reflected by the percentage of juveniles in the flocks, and the presence of Siberian Crane foster chicks.

(B) The ecological requirements of these cranes be determined and the most important water reservoirs used as roosting areas by the cranes be identified and designated as crane reserves.

RESOLUTION REGARDING THE EASTERN SARUS CRANE

RECOGNIZING that the Eastern Sarus Crane (*Grus antigone sharpii*) has reached critically low population levels throughout its entire range in Southeast Asia and that the cranes have been extirpated from Malaysia, the Philippines, and Thailand,

KNOWING that a substantial flock of Eastern Sarus Cranes survives in northeastern Australia and that the species is being propagated in captivity at the International Crane Foundation, the 187 participants from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

ENCOURAGE the governments and private organizations in China, Thailand, Burma, Kampuchea, Laos, Malaysia, the Philippines and Vietnam to:

(A) Assess the current status of this species in each of the countries where the status is yet unknown.

(B) Protect the surviving cranes and their delicate wetland habitat.

(C) Work cooperatively with other countries particularly Australia, and with the International Crane Foundation to develop long-term reintroduction and management programs for the Eastern Sarus Crane in countries where the birds were previously found.

RESOLUTION ON THE MANAGEMENT OF COMMON CRANES IN THE ISLAMIC REPUBLIC OF IRAN

RECOGNIZING the potential of the ubiquitous Common Crane (*Grus grus*) as foster parents for the rare Siberian Cranes (*Grus leucogeranus*) by substituting Siberian Crane eggs into the nest of the Common Cranes in the USSR, in order to establish new and more secure flocks of Siberian Cranes, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

REALIZING that the interior wetlands of southwest Iran are major wintering areas for Common Cranes,

RECOMMEND that the Department of the Environment of the Islamic Republic of Iran, protect the Common Cranes and their habitats so that the population may eventually be of greater benefit to the Siberian Cranes, and that

RESEARCH efforts be continued in the Islamic Republic of Iran to color mark Common Cranes, so that their breeding grounds in the USSR can be more precisely determined.

RESOLUTION REGARDING THE SIBERIAN CRANES THAT WINTER IN THE ISLAMIC REPUBLIC OF IRAN

RECOGNIZING the excellent conservation measures taken by the local people near Ferydon-Kenar and the Department of the Environment of the Islamic Republic of Iran, to protect the several Siberian Cranes that continue to winter in the south Caspian region, and

AWARE that the world population of this endangered species numbers fewer than 300 birds, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND that surveys of the abandons near Ferydon-Kenar be conducted in late winter to confirm that the Siberian Cranes have migrated from the area before the late-winter waterfowl shooting is initiated, so that the survival of the cranes is not jeopardized by the onset of a waterfowl hunt preceding the migration of the cranes.

RESOLUTION TO THE EUROPEAN COMMUNITY (EC) COMMISSION, BRUSSELS REGARDING THE EUROPEAN CRANE

The 187 delegates from 24 nations attending the International Crane Workshop, February 5-11, 1983, at Keoladeo National Park, Bharatpur, India,

INFORMED that large numbers of *Grus grus* migrate through the EC;

INFORMED that the crane disappeared as a breeding bird in the last centuries from Ireland, United Kingdom, the Netherlands, Italy and Greece;

NOTING that these cranes need protection during their flight from the northern breeding areas to the southern wintering areas and reverse;

NOTING that the crane according to the EC-bird directive has to be protected;

ASKS the EC - Commission:

(A) to ensure the few breeding areas in FRG, Denmark and maybe the remaining sites in Greece;

(B) to finance according to the EC-bird directive a study on their migration routes in order to ensure the resting places on their routes;

(C) to encourage the EC - countries to do everything for the further protection of *Grus grus*, i.e. to finance the management of further breeding and resting places.

RESOLUTION ON COMMON CRANES WINTERING IN SPAIN

RECOGNIZING the importance of Spain as the major wintering area of the Common Cranes (*Grus grus*) that breed in northwestern Europe; and

COGNIZANT of the threats to the crane habitats in Spain as a consequence of the felling of oak forests, the expanded use of pesticides, and the attrition of aquatic habitats, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983;

RECOMMEND that to assure the survival of the cranes in harmonious environment with mankind in Spain, the following suggestions are followed:

(A) Every three years a study be made to census the crane population, its productivity and its distribution.

(B) Establish five or six crane sanctuaries including Laguna de Gallocanta in which land-use practices could be monitored and curtailed to ensure the protection of the cranes.

(C) Investigate the long-term effects of pesticides and fertilizers on the cranes.

RESOLUTION ON THE WATTLED CRANES IN ZAMBIA

CONSIDERING that fewer than 7,000 Wattled Cranes (*Bugeranus carunculatus*) survive in the world, and that almost half of this population depends on the Kafue Flats of Zambia for breeding habitat, the 187 delegates from 24 countries attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

BEING APPRAISED that dams constructed at either end of the Kafue Flats may negatively alter the delicate hydrological cycles of the Flats upon which the breeding of the cranes is determined,

URGE that a study be undertaken concerning the re-evaluation of water management on the Kafue Flats with the nesting requirements of the cranes kept in mind.

SPECIFICALLY it is recommended that the Ministry of Power, Transport and Communications, Ministry of Tourism, Ministry of Agriculture and Water Development, the Zambian Electrical Supply Corporation, the Central African Power Corporation, the Kafue Basin Research Committee, the Department of National Parks and Wildlife and other interested parties should meet to formulate a plan for the effective management of the Kafue Flats for balanced maximum utilization, including the maintenance of natural habitats for the 3,000 plus Wattled Cranes.

RESOLUTION REGARDING WATTLED CRANES IN ETHIOPIA

REALIZING that the Wattled Crane is an endangered species over much of its African range, and has already been extirpated from many areas of former habitation, the 187 delegates from 24 nations participating in the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND that in view of the scarcity of information on the Wattled Cranes in Ethiopia, that the following activities be undertaken:

(A) A survey be conducted to determine the distribution and numbers of Wattled Cranes.

(B) The most important wetlands used as breeding habitat for Wattled Cranes be identified and then protected.

RESOLUTION OF THE CONSERVATION OF THE CROWNED CRANE IN NIGERIA

WHEREAS the Crowned Cranes (*Balearica pavonina*) is a treasured bird in Nigeria, we the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

APPRAISED of the recent extinction of the Crowned Cranes in several regions and its serious decline in all other areas of its former Nigerian range,

EARNESTLY implore the Federal Government to embark upon appropriate courses of action to protect and conserve for posterity the remaining population in your country. We would respectfully advise the Federal and Regional Governments of Nigeria that in our opinion the appropriate course of action shall be:

(A) To initiate studies into the Crowned Cranes' actual range, abundance and status in Nigeria;

(B) Thereupon to formulate a comprehensive management policy in relation to competing land-use claims; and

(C) Implement conservation measures as a matter of greatest urgency so that the Crowned Crane may be saved from imminent extinction in Nigeria.

By these means the heritage of Nigeria shall be enriched and her peoples never deprived of a majestic and admired bird species which features so prominently in her affections, heraldry and folklore.

RESOLUTION ON CAPTIVE BREEDING CENTERS FOR CRANES

RECOGNIZING the endangered status of a significant number of species and subspecies of cranes, and realizing the importance of establishing captive breeding programs as a safeguard against their extinction, the 187 delegates from 24 nations attending the International Crane Workshop at Keoladeo National Park, Bharatpur, India, February 5-11, 1983,

RECOMMEND that breeding centers throughout the world adopt the following guidelines in the cooperative management of their captive crane populations:

(A) Following the examples of the Tokyo Zoological Society, the Oka State Nature Reserve and the New York Zoological Society that have established and maintained excellent stud books for the Red-crowned Crane (*Grus japonensis*), Siberian Crane (*Grus leucogeranus*) and White-naped Crane (*Grus vipio*), respectively, stud books should be established for four (4) endangered species, the Whooping Crane (*Grus americana*), Black-necked Crane (*Grus nigricollis*), Hooded Crane (*Grus monachus*), Wattled Crane (*Bugeranus carunculatus*); and three endangered subspecies, the Eastern Sarus Crane (*Grus antigone sharpii*), Mississippi Sandhill Crane (*Grus canadensis pratensis*), and Cuban Sandhill Crane (*Grus canadensis nesiotes*).

(B) A minimum captive population of thirty (30) breeding pairs of each species and subspecies should be maintained among the various breeding centers.

(C) Efforts should be made to increase productivity of captive populations to provide cranes for zoos, THEREBY removing a needless drain in the wild crane populations.

(D) Cranes should be actively exchanged among the breeding centers to prevent inbreeding as well as avoid the concentration of a single species at any one or two centers.

(E) Additional stocks of Black-necked Cranes (*Grus nigricollis*) and Eastern Sarus Cranes (*Grus antigone sharpii*) should be removed from the wild as eggs to establish suitable captive breeding populations.

(F) Research on the captive populations should be continually expanded to improve our understanding and management of cranes.

(G) Communication between breeding centers should be regularly exchanged to maximize information flow and promote and facilitate cooperative efforts in crane research and propagation.

CHAPTER I

EDITORS' INTRODUCTION: CRANES OF ASIA AND AUSTRALIA

Aside from the Common Crane and the Siberian Crane to which entire chapters are devoted in this volume, and the Sandhill Crane that ranges into northeast Siberia, six other species of cranes (Demoiselle, Black-necked, Red-crowned, White-naped, Hooded, and Sarus) are also native to Asia. These cranes, as well as the Brolga from Australia, are included in this chapter.

Hundreds of thousands of Demoiselle Cranes winter in India, then migrate over the Himalayas and Hindu Kush Mountains to the steppes of central Asia where they breed in a diversity of habitats, including grasslands, semi-deserts, wetlands, and recently in agricultural fields.

From the familiar Demoiselles the chapter leads to the least known of cranes, the Black-necked Cranes of the Tibetan Plateau. For the first time in an international publication, basic biological information is presented on the life history and distribution of this alpine crane that predominantly breeds in China, but also in eastern Ladakh in India.

Perhaps the most magnificent and treasured of cranes is the Red-crowned Crane of temperate east Asia. Unfortunately the vast freshwater wetlands on which these space-demanding birds breed, is in great demand for agricultural development. The International Crane Workshop marked the first meeting of Soviet, Chinese, Korean and Japanese specialists upon whose recommendations the fate of the wetlands rests. As a consequence of the plans developed at the Workshop in 1983, a coordinated international census of the nesting Red-crowned Cranes was made in 1985 from which it is estimated that the world population is perhaps 1000 birds.

Japan is internationally recognized for its contribution to crane conservation, particularly on account of the winter feeding of Red-crowned Cranes in Hokkaido and White-naped and Hooded Cranes on the southern islands. Since the early 1950s, all three species have continued to increase as a consequence of the feeding. The behavior and the ecology of these cranes, however, have greatly changed as the birds spend most of their time at or adjacent to the feeding stations. Consequently, reports on newly-discovered flocks from China and Korea provide important information on the natural biology of wintering cranes. Cranes in Japan must have behaved in a similar manner before artificial feeding started.

The tallest flying creature on earth, the Indian Sarus Crane, is strictly protected in most regions of northern India where it thrives on man's agricultural landscapes. The Eastern Sarus Crane of southeast Asia, however, is endangered on the mainland and in the Philippines, and only survives in considerable numbers in northern Australia where it comes into sympatry with the native Brolga. The chapter concludes with two papers on the needs of these nonmigratory cranes.

Regional Working Groups have been established to address specific research and conservation activities. These groups include:

Soviet Working Group on Cranes
c/o Dr. Vladimir Flint
All-Union Research Institute of Nature
Conservation and Reserves
USSR Ministry of Agriculture
Znamenskoye-Sadki, 142790
P.O. Vilar, Moscow, USSR

India Crane Study Group
c/o Prakash Gole
1 B Abhimanshree Society
Pashan Road, Pune, 411 008
India

Australian Crane Working Group
c/o Don White
Fisheries and Wildlife Division
Serendip Wildlife Research Station
P.O. Box 2, Lara, Victoria 3212
Australia

Special Committee for Protection
of Cranes in Japan
c/o Noritaka Ichida
Wild Bird Society of Japan
Aoyama Flower Building
1-1-4, Shibuya, Shibuya-ku
Tokyo, Japan

Sarus Crane Working Group
c/o Bubphar Amget
Wildlife Conservation Division
Royal Forestry Department
Bangken 9, Bangkok, Thailand

China Working Group on Cranes
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THE DEMOISELLE CRANE IN KAZAKHSTAN AND CENTRAL ASIA

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ABSTRACT

The Demoiselle Crane (*Anthropoides virgo*) is widespread in Kazakhstan and Central Asia. It has, however, declined in much of its range, although numbers now seem to be stable in some areas like western Kazakhstan, where some regions are still almost devoid of people, and habitat has not been transformed by agriculture. In eastern Kazakhstan, Demoiselle Cranes have taken to nesting in agricultural areas, including fields. Unfortunately, so little is known about the population and its distribution in Kazakhstan and Central Asia that quantitative estimates cannot be made.

INTRODUCTION

This document is a compilation and analysis of data about the Demoiselle Crane (*Anthropoides virgo*) accumulated over the past quarter century, during which this species' decline became first discernible and then obvious, resulting in its entry in the Red Data Book of the Kazakh S.S.R. (Krasnaya kniga Kazakhskoi SSR). This comparative study looks at three phases in time: 1960, 1973, and the early 1980s. The first date denotes the publication of Volume 1 of *Ptitsy Kazakhstana* (Birds of Kazakhstan) (Dolgushin 1960), which includes comprehensive data until the end of the 1950s. The second date is that of the scientific-technical conference held in Alma-Ata on 'Vanishing and Rare Animals and Birds of Kazakhstan: Measures for their Protection and Recovery.' The conference summarized information available at that time about the population and distribution of rare species, including the Demoiselle; the proceedings were published in 1977. The Alma-Ata meeting was the inspiration for the Kazakh Republic's Red Data Book and for the inclusion of the Demoiselle Crane in 1978.

To gather information about the current status of the population and distribution of the Demoiselle in Kazakhstan, I made observations in the foothills of the Tien-Shan Mountains and the Dzhungar Alatau Mountains, in the Zaisan and Alakol depressions and in the Tengiz-Kurgal'dzhin depression. Also, other ornithologists working in various parts of Kazakhstan were consulted. Recent, unpublished data about cranes were provided by the following persons: for the Altai Mountains and their foothills: N.N. Berezovikov; for Alma-Ata Region: B.M. Gubin, S.N. Yerokhov, V.M. Zverev, and E.F. Rodionov; for Dzhambul Region: V.A. Denkhold and a group of students from Karaganda University; for Kurgal'dzhin Nature Reserve [zapovednik]: Ye.N. Volkov; for Naurzum Nature Reserve:

N.S. Gordienko; for Gur'yev Region: A.S. Klimov, N.Z. Nastyukov, and Ye.G. Samarin; for Ural Region: V.L. Shevchenko. Some information about migration of Demoiselles in the Central Asian republics was provided by A. Karavaev (Turkmenia), D.N. Kashkarov (Uzbekistan), and A.K. Kydyraliev and V.I. Toropova (Kirghizia).

'The Demoiselle Crane is distributed mainly in the southern steppes and semidesert of Eurasia, from Dobrudzha and Moldavia to Trans-Baikal,' according to the first volume of *Ptitsy Kazakhstana* (Dolgushin 1960). However, already in 1963, A.M. Sudilovskaya (1963) pointed out the severe decline in the European part of the Demoiselle's range, and after another 12 years Ye.V. Kozlova noted: 'Earlier, this species inhabited the entire steppe zone of the Palearctic, all the way to the west, but today it exists (outside Mongolia) only in Kazakhstan (and a few places in Kirghizia), in the southern Volga region, in Ciscaucasia, and in the southern Ukraine. There are isolated patches of range in Asia Minor and on the mountain plateaux in Algeria' (Kozlova 1975).

In Kazakhstan, the Demoiselle nests in the southern half of the steppe zone and in semidesert. The northern border of its range has been delineated hy observations near the town of Ural'sk and Lake Chelkar; in the Aktiubinsk steppe it follows the republic's boundary; in Kustanai it passes close to Naurzum, then proceeds between Atbasar and Kurgal'dzhino, south of Tselinograd and north of Karaganda on to the Irtysh River near the village of Yamyshevo, about 50km south of Pavlodar. The southern border of the range stretches from the Kamysh-Samar lakes and Kalmykov, following the course of the Uil River, crossing the Emba where the Temir flows into it, then south of Berchogur Station 'where the Irgiz and Turgai merge, 50km north of Karsakpai, to the confluence of the Sarys and Kengir, Mount Bulattau, Mointa Station, and then 50-100km north of Lake Balkhash, up to Lake Sasykkul and the Alakol depression' (Dolgushin 1960).

In addition to the areas described above, where the Demoiselle is found in fairly good numbers, it also nests farther south, but only sporadically: in the foothills of the Dzhungar Alatau mountains, in several wide intermountain plains of the Tien-Shan (Syugatin, Dzhalanash, Karkarin), in steppe areas of the Chu-Ilii mountains - Anarkhai, Khantau, etc. The most southwestern Demoiselle nest in Kazakhstan is in the Telikol lakes region (Spangenberg & Feigin 1936). This prompted A.M. Sudilovskaya (1951) in the second volume of *Ptitsy Sovetskogo Soyuza* (Birds of the Soviet Union) to describe the Kazakhstan portion of the southern border of this species' range as reaching from the Aral Sea almost up to the Syr-Dar'ya River and farther to the northern foothills of the Tien-Shan, including wide expanses of desert (the Muyunkumy, the Betpak-Dala, the Southern Balkhash) where the Demoiselle almost never nests. In this same compendium, on the basis of an adult bird taken by N.A. Severtsov on 11 July (year not given) near Khodzhent (now Leninabad), it was suggested that the Demoiselle might nest in northern Tadzhikistan, but today it is known that it definitely does not (Ivanov 1969; Abdusalyamov 1971).

South of Kazakhstan in the USSR, the Demoiselle is known definitely to nest only in Kirghizia. Here about 10-12 pairs of this crane nest in a sanctuary at Lake Sonkol, while isolated pairs nest in the Atbashin, Susamyr, and Chatkal valleys, and also along the left and right banks of the Naryn River up to the Fergan Range. In other parts of Kirghizia, where the Demoiselle had been observed nesting in the 1950s and '60s (Yanushevich et al. 1960), it is no longer found, not even on the Issyk-Kul and Pokrov watershed uplands. In all there are probably no more than 25 pairs of Demoiselles nesting in Kirghizia.

REGIONAL DISTRIBUTION AND NUMBERS

Caspian Sea Area (Ural, Gur'yev, and Mangyshlak Regions). In the 1960s, the Demoiselle Crane's nesting areas between the Volga and the Ural rivers and in the Trans-Ural area underwent significant changes. By 1973, the species had ceased to nest in the Kamysh-Samar lakes area and in the valley of the Uil (Shevchenko et al. 1977). Over the course of 20 years, from 1953 to 1972, a group of zoologists noted Demoiselles nesting only in the drowned river valleys of the Greater and Lesser Uzen and along the Kushum as far north as Yanaikino. Numbers are small: on 21 April 1969 from Chapaevo to Furmanovo to Nizhnaya Kazanka, a distance of 240km, only 7 pairs were counted (Shevchenko et al. 1977).

Similar information comes from V.A. Borisenko (1977), who made a 3100km trip in the Volga-Ural interfluve in April and May of 1966 and noticed only 14 cranes, but 50km west of Kalmykovo (the Aigyr wintering area) he saw 5 pairs, nesting within a 4-5km radius of a settlement. On a route from Aktyubinsk to Uralsk between May and August in 1967 and 1968 only two Demoiselle pairs were observed: 50 and 20km east of Dzhambeita (Borisenko 1977).

In the 1970s, V.L. Shevchenko (pers. comm.) made 13 automobile trips, covering 1105km in all. He recorded 50 Demoiselle Cranes and believes that the population of this crane has stabilized in recent years, although of course it was much higher in the 1950s.

Very interesting information was gathered in the Gur'ev Region. Here, nesting Demoiselles were found much farther south than the known limits of the range of this species. For instance, at Kushen, 20-25km east of Karmanovo, a pair of Demoiselles was seen with two young, which one of the adult birds shielded with half-opened wings as it led them away from the vehicle. Other sightings: 10 June 1971 - three lone cranes at Zhaman-Kuduk in the Trans-Ural, just north of the town of Zelenyi; 14 May 1970 - a pair and a lone bird north of Lake Aisory; 29 May 1973 - a pair 15km east of Topoli; 8 June 1973 - a pair at Barsuk.

There is no doubt that Demoiselles nest in these places in the Ural region and Trans-Ural region at this time. Near Bagyrdai and Aksai Demoiselles were observed from a helicopter regularly. Sightings in 1980: 14 and 15 April - dancing of pairs in Aktanbasa and Masali Districts (on the Karmanovo plain); 29 April - a pair in Kyzylbasmoll (10km west of Zelenyi); 7 May - in Anshibai (6km west of Baklan'ii), a pair was clearly performing a distraction display; 18 July - three Demoiselles were met near Karabau. All of these sightings were made on the clayey plain between the Volga-Ural sands and the Ural River. Obviously, in this area 100-130km south of the presumed boundary of the species' range, nesting Demoiselles are not so rare.

Aktyubinsk Steppe and the Aral-Turgai Gulf (Aktiubinsk, Kustanai, and Turgai Regions). In the 1950s, the Demoiselle was a characteristic bird of the uncultivated Aktyubinsk steppe and Mugodzhar where it nested north of the 48th parallel. At the end of the 1960s and the beginning of the 1970s its population declined sharply here, although it remained in fairly good numbers east of the town and river of Irgiz, where broods continued to be seen frequently (Varshavskii et al. 1977).

Following a route from Aktyubinsk to Karabutak, Irgiz and Nura (total distance 550km) at the beginning of July 1968, V.A. Borisenko counted 14 cranes, primarily near Irgiz and Nura; in the basins of the Turgai and Uly-Zhilanshik rivers and along the Tersakkan and Kokpetky rivers to Lake Tengiz, on a 6700km journey made between May and August 1965, he counted 99 birds (Borisenko 1977). In 1977, E.M. Auezov (1977) encountered five families of Demoiselles in the lower reaches of the Turgai; three of the families had two chicks each, and the others one each. In the middle of summer Auezov fairly often saw flocks of several dozen wandering Demoiselles in wheat and corn fields.

It has not yet been proven that the Demoiselle nests in the Naurzum steppes (Dolgushin 1960). Census data gathered by V.F. Ryabov show that this crane was found in 1936 in semidesert and in regions where *Agropyron* grows, but by 1963 it was absent from both habitat types. This author makes direct reference to the disappearance of the Demoiselle Crane along with the Great Bustard, the Little Bustard, and eagles, for which he considers the reason to be direct or indirect human pressure (Ryabov 1974).

At the Naurzum Nature Reserve a few Demoiselles nest in two regions: on the steppe north of Lake Chushkaly, and near Lake Zharman (a nest with eggs has been found and chicks have been seen). The birds prefer the wormwood-grassy areas, usually fairly far from water reservoirs (5 to 15km), but close to ponds for watering cattle. The negative consequences of such close association have already been noted by E.N. Golovanova (1980) while she was working in the woods of Naurzum Reserve. Gordienko's observations are indirect corroboration: of 16 pairs of Demoiselles encountered in June-July, 1972-1976, only six had chicks (in one case, two chicks; one chick in all the others), although some more chicks may have been hiding in high grass. N.S. Gordienko calculates the total number of Demoiselles nesting in the reserve at 2-5 pairs (in 1975 and 1978 there were 2 pairs each year; in 1977 and 1979, 3 pairs each year; in 1980, 4 pairs; in 1976, 5 pairs).

Central Kazakhstan (Akmolin, Karaganda, and Dzhezkazgan Regions). In the western part of Akmolin Region, in the middle reaches of the Tersakkan River, in 1957-1958 Demoiselle Cranes were distributed fairly widely, although numbers were small. Here Chekmenev (1960) made interesting ecological observations at 4 nests, and he remarked, even then, on the urgency of instituting conservation measures for this species. S.G. Panchenko (1977) recalls the rarity of Demoiselle Cranes in Karaganda Region in 1952-1954: he found them nesting only at Lake Chushkokol, 180km southwest of Karaganda.

On a 750km trip from Dzhezkazgan to Amangel'd in the middle of May 1971, 19 Demoiselles were counted; at the Brali weather station (at the mouth of the Dul'galy-Zhilanshik), within binocular range of the expedition's camp, three pairs of Demoiselles were nesting (Borisenko 1977). The same author saw four Demoiselles in August 1971 between Tselinograd and Kurgal'dzhino, at the very northern edge of their range. West of Lake Tengiz in June-August 1972, E.M. Auezov (1977) saw Demoiselles very often. Here on the fields of the Abai and Armavir collective farms he would sometimes see several hundred cranes in a day.

Information on the current status of the Demoiselle population in this region was provided by E.N. Volkov (pers. comm.) (*Table 1*).

Table 1. Sightings of Demoiselle Cranes in and near Kurgal'dzhin Nature Reserve.

Date	Number of Demoiselle Cranes seen
29/5-69	pair and a single
29/4-70	3 singles
28/4-71	3 pairs
3/5-71	pair
27/4-72	pair and 3 singles
3-4/5-74	5 pairs
17/4-75	10 pairs
12/4-77	5 pairs and a group of 6 birds
23/6-79	2 pairs
24/6-79	1 pair
25/6-79	1 pair

Censuses were made from roads that encircle the refuge. Volkov calculates that the density of Demoiselles on the sections of the reserve that are steppe or dry salt marshes (total area about 30-35,000ha) is not much higher than in places relatively thinly settled. To this we can add our observations from travelling by car from Karazhar to the western shore of Lake Tengiz in June 1970, and again in June 1980: on both trips we saw three families. The population of Demoiselles in this region is stable.

Of particular interest is E.N. Volkov's account of Demoiselles congregating at Common Crane (*Grus grus*) moulting areas: 'Groups of Demoiselles (3 birds, 9, 12) were seen in May and June near ponds on the steppe and in cultivated areas. Flocks of Demoiselles were found at Common Crane moulting places in the northeastern bay of Lake Tengiz (31 May 1976). In one hollow used for hay-cutting, situated between fields near the salt lake Zhumai, on 25 June 1972, we found many crane wing feathers, including those of Demoiselles. Obviously, a large group of these birds had stayed here for some time. A male Demoiselle, taken here on this day from an arriving pair was moulting contour feathers, tail feathers, and wing feathers.' As is known, the Demoiselles, in contrast to the other Soviet crane species, do not flock together to moult, since they moult gradually. Volkov's report does not really contradict this, because there may be differences in the rate with which the moult occurs in different age/sex groups. It may be that non-breeders do gather together for a moult that progresses faster than in other birds.

In Karaganda Region, observations made by students of the local university over a period of years (1974-1980) suggest that nesting Demoiselles are not rare.

In Dzhezkazgan Region, according to E. Balabatyrov, (pers. comm.), Demoiselles were known to nest in 1973-1979 near the Karatal Collective Farm in Aktogai District. From May to August he saw everyday between 2 and 20 cranes, usually foraging in fields of perennial grasses near a marsh. In 1973-1974, crane nests with eggs were found here. The current decline in numbers of Demoiselles in this place is caused by increased disturbance (hay cutting, tractor traffic) and deliberate shooting of adults for meat.

The Altai Mountains and Zaisan Depression (Eastern Kazakhstan Region). 'In the Kazakhstan part of the Altai, there is no information about the distribution of the Demoiselle, although it is very likely that it nests in the Bukhtarma, Naryn, and Kurchum valleys' — according to *Ptitsy Kazakhstana* (Dolgushin 1960). This work mentions nesting Demoiselles in the foothills of Tarbagatai and in Chiliktin Valley. A decade and a half later, in an article devoted to the rare birds of Eastern Kazakhstan, I.F. Samusev (1977) also speaks only of the infrequency of nesting Demoiselles in Zaisan.

Observations of N.N. Berezovikov (pers. comm.) indicate that the Demoiselle is one of the typical inhabitants of the steppe and semidesert of Eastern Kazakhstan, where it nests not only in the Tarbagatai, the Chiliktin Valley, and the Zaisan Depression, but also in the southwestern foothills of the Southern Altai, in Kalbin upland and in the Western Altai, on the right bank of the Irtysh River between the mouths of the Ub and Ulb. It is particularly interesting that along with a decline in the population of this species a marked tendency toward its inhabiting agricultural areas has been observed. I take the liberty of quoting here from N.N. Berezovikov (in press):

> 'In the steppe foothills of the Western Altai, and in the more agricultural areas of the valley of the Irtysh, Demoiselles nest more frequently every year. In spring and summer of 1972 a pair of them was constantly present on the curcurbit field at the mouth of the Orlovka River between Berezovka and Pervomayskoye. From 1976 to 1979 cranes regularly nested on the left bank of that river (near Poboka). In 1976 one nest with two eggs was found on 28 April near a grain field at Barashka. Cranes were seen here in later years too. In 1977, a Demoiselle nest was found in fields north of Berezovka. In May of that year they were apparently nesting in wheat fields near Praporshchikovo, not far from the runway at the Ust-Kamenogorsk airport, and in 1979 they were found near Opytnoye Polye.
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> In the Southern Altai, on spurs of the Kurchum Mountains, between Karoi and Arkhipovka, in 1973-1979 Demoiselles nested near the headwaters of the Kara River (Aktaincha) on a short grass steppe meadow near a stock farm. In the southwestern foothills of the Narym Mountains in cultivated areas between Kurchum and Karaozek (toward Sergeevka), cranes were seen on 29 May 1980, displaying behaviour typical of birds disturbed while nesting.
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> On the Kalbin uplands in 1973-1979 Demoiselles were frequently seen in the cultivated land on the left bank of the Irtysh between the settlements of Predgornoye and Tavriya. In May-June 1979, nesting pairs were seen in fields near the towns of Menovnoye, Akhmirovo and Gerasimovka. In the western section of Kalba a pair was seen on 18 April 1977 near Georgievko.

In Southern Zaisan, from 19 to 22 April 1977, a nesting pair was seen in Cheegrass-chingil steppe, used as pasture, between Sarzhira and Bakas (north of the town ofan). In this same area Demoiselles live on fields and the surrounding steppe at Karabulak, near the Sarybulak milestone, at Satpai, and in the vicinity of Kamyshzavod (A.Ye. Samoilov, pers. comm.). In eastern Zaisan between Buran and Chernyaevka some Demoiselles stayed in an old cornfield on 25 - 26 April 1977. On the northern edge of the Zaisan depression, adjacent to the Kurchum Mountains, in 1977-1980 pairs of Demoiselles were seen several times in pastures near Takyr, Kalguta, and Razdol'nyi. In wheat fields between Zelenlye and Malyi Akkuduk (Kurchum District) birds were seen in spring and summer in 1967, and then regularly in 1973-1978.'

To this enumeration of Demoiselle nesting places in the Kalbin Altai can be added one pair with unfledged chicks seen on 12 June (year not specified) on the flood plain of the Kyzylar River (Yegorov & Borisov 1979).

As the above data show, the Demoiselle Crane in this region inhabits not only wild but also cultivated areas, which can be divided into two types, pasture and grain fields. N.N. Berezovikov (in press) has found several Demoiselle nests in fields (e.g. between the villages of Berezovka and Pervomaiskoye in 1976, north of Berezovka in 1977, etc.).

In the valleys of the Bukhtarma and Narym the Demoiselle has not been found since the beginning of the century (N.I. Yablonskiy 1901, Berezovikov, in press). However, Yablonskiy saw a Demoiselle brood in July 1901 on the north-east shore of Lake Markakol, between the town of Urunkhaika and Tikhushka Creek. Today there are no Demoiselles on the Markakol shores, but 30km north of the lake, in the steppe valley of the Kara-Kaba River near Bobrovka, N.N. Berezovikov saw a family with two fledged young (nearly adult size) on 20 July 1979.

In the Zaisan depression the population of Demoiselles at present appears to be very low. In August 1980, we crossed the depression from Buran to Zaisan, Kokpekta and Georgievo and saw not one crane. The same holds for the Chiliktin Valley: after spending the entire day of 30 August driving 200km in search of Demoiselles we found none, and local people told us that cranes are rare here.

Balkhash-Alakol' Interfluve (Alma-Ata, Taldy-Kurgan, and extreme southern Semipalatinsk Regions). *Ptitsy Kazakhstan* says this about the distribution of the Demoiselle in this region: 'It is encountered in the Alakul' [sic] depression, but not in the Southern Balkhash area. Widely distributed in the foothills of the Dzhungar Alatau, whence it moves along river valleys to the Ilii Valley; along the Malai-Sary it goes rather far into the Balkhash area. It is common in the wide valleys of the Tien-Shan: the Syugatin, Dzhalanash, and Karakin, where it is found almost up to 2000m above sea level. It also nests in steppe areas of various mountain groups of the Chu-Ilii Mountains (the Anarkhaya, Khantau, etc.)' (Dolgushin 1960).

There is very little information about Demoiselles nesting today in this region. In June 1970 on Kamenyi Island in Lake Alakol five pairs nested, each nest having two eggs; at Lake Ul'ken-Aral-Tiube 5-8 pairs nested (Auezov & Grachev 1977), and along the eastern shore of this lake, on a 150km route from Zharbulak to Makanchi and Ucharal, we saw only one pair. We saw no cranes on a 300km route from Andreevka to Ucharal and Ayaguz in August 1980, and none on a route in the Dzhungar Alatau foothills (from Saryozek to TaldyKurgan, Sarkand and Andreevka), although bird censuses are constantly made by car here (usually of Falconiformes and Coraciiformes). Along this last route only some of the land is suitable for Demoiselles, but there is no doubt that Demoiselles are very scarce here.

Of greater interest is the little information available on Demoiselles nesting in Alma-Ata Region. I.A. Dolgushin (1960) referred to summer records of Demoiselles on the Kara Plateau, northeast from what was then Iliisk (now Kapchagai), but nesting here has still not been documented. Two Demoiselle pairs with downy chicks were seen in June 1974 on the southern shore of the Kapchagai Reservoir, about 15km south of Nikolaevka.

Demoiselles very probably nest on a small plateau 110-150km west of Alma-Ata, along the Alma-Ata Frunze road, and in the Turgen River valley, 5-6km below the settlement of the same name. In June 1978, one bird was seen in this latter place on several occasions, leading a dog away by flying 50-100m ahead of it. All these facts point to the need to make a more careful survey of Alma-Ata Region.

Betpak-Dala, Muyunkumy, and the Foothills of the Western Tien-Shan (Dzhambul, Chimkent, and Kzyl-Ordy Regions). *Ptitsy Kazakhstana* says of Demoiselles nesting here: 'In the desert zone, as a rule, the species is absent, but lone pairs sometimes do nest here. Such an instance is known for the Telikul Lakes area, where a nest was found; during nesting season the species has been observed in northern Betpak-Dala...' (Dolgushin, 1960). No additional data about this area have come to light in the intervening 20 years.

In Betpak-Dala, V.A. Borisenko (1977) saw 8 cranes between 19 April and 5 May 1965 along a 3300km route: two on the Chu River and 6 along the Koktas. Probably these were migrants, since on 7 May 1965, the same author recorded a flock of 53 around Baikonur, and a flock of 24 near Karsakpai at the end of April.

It must be mentioned that migrating Demoiselles are very obvious here, particularly in spring (see below). There are no good data about nesting, except for I.A. Dolgushin's reference to a Demoiselle nest found at the Telikol Lakes near Kzyl-Ordy half a century ago. One can say with certainty, only that the Demoiselle nests nowhere in the high foothills of the Talass Alatau Range. However, for several years we observed Demoiselles during spring migration through the Chokpak Pass, at the junction of the Talass Alatau and the Karatau Range. Several times we saw a pair break out of the migrating wedge and, constantly exchanging calls with the other birds, as if bidding them farewell, set off northward along the Dzhuval Plateau which lies between two parallel ridges of the Syrdar' Karatau. We suppose these must have been pairs heading for their nesting area; a survey of the Dzhuval Plateau itself and of the mountain steppes of both ridges of the Karatau would reveal whether or not we are right. It would be especially desirable to survey the northwest end of the Karatau, where it comes into the Telikol Lakes area.

MIGRATION

Demoiselle migration in Kazakhstan and the Central Asian republics is not much better studied than their distribution on nesting grounds. One basic feature is the extreme unevenness of distribution of numbers of migrants in space and time: in some places large numbers of birds are seen, at others hardly any at all. Also spring migration is observed far more frequently than autumn migration.

Mass migration of cranes is observed only in the foothills and in some valleys of the Tien-Shan. In southern Uzbekistan, in the region of Termez, cranes are almost never seen in spring; in Turkmenia, between the valley of the Murgab and the Caspian Sea, Demoiselles are very scarce or completely absent. But in the Karshin steppe and along the entire western edge of the Tien-Shan mountain system, cranes move in very large numbers, and 90-95 percent of them are Demoiselles (the remaining 5-10 percent are Common Cranes). A particularly large number of Demoiselles traverses the Chokpak Pass between the ranges of the Talass Alatau and the Karatau in the Western Tien-Shan. Counts made during the spring in 1969-1972 have yielded numbers of birds ranging annually between 4500 and 11,500 birds (Gavrilov 1977). There are probably many more than this since on a single day (11 April 1968) we counted about 4500 Demoiselles here (Kovshar 1972), flying in daylight; migrating flocks could also be heard at night.

Westward 2km-wide area of the flood plain of the Keles River, 7750 cranes were counted between 12 March and 28 April 1972; 85 percent were Demoiselles (Kashkarov et al. 1977); and here too migration was also recorded at night.

From the foothills of the Western Tien-Shan the bulk of the cranes goes on to the northern foothills of the Northern Tien-Shan, where enormous flocks of migrating Demoiselles are seen at Sorbulak, 60km northwest of Alma-Ata: on 10 April 1979, about 3000 cranes took shelter in a strip of forest along the northern shore of a lake (there was a blizzard, and the temperature fell from 18° to -12°C) (S.N. Yerokhov, pers. comm.). From here the cranes' route must go to the northeast, since masses of migrating Demoiselles are next observed regularly in the Alakol depression, on the northwest shore of Lake Alakol.

The second major migration route is along the valleys of the Inner and Central Tien-Shan. Large numbers of Demoiselles are recorded at Issyk-Kul (Yanushevich et al. 1959) and in the upper reaches of the Tekes River, where flocks as large as a thousand are seen. E.I. Gavrilov (1977) suggests that these cranes fly eastward along the Tekes and over our border into Mongolia. In other places in Kazakhstan migration is light. There is reason to believe that most of the cranes, especially in autumn, fly so high that they cannot be seen. Furthermore, a significant proportion of the migrants fly at night, as shown by the preliminary data gathered by K.V. Bolshakov and A.P. Gistsov (pers. comm.) while observing migrants against the full moon in Kazakhstan and Kirghizia.

CONCLUSION

Considering the overall status of the Demoiselle Crane in Kazakhstan, it must be acknowledged that along with the obvious sharp decline in numbers of this species over a significant proportion of its range in recent years some stabilization of population has been observed in a number of places — for example, in Western Kazakhstan and in several places in Central and Eastern Kazakhstan. The basic reasons for this positive development in the Volga-Ural confluence are the increase in the level of the Caspian and the filling up of the Kamysh-Samar lakes, which made many steppe areas suitable for nesting by Demoiselles and other steppe and semi-desert birds. In addition, a large expanse of the Volga-Ural confluence is at present almost devoid of people and habitat has not been destroyed by agriculture. In Eastern Kazakhstan the outlook is good because the Demoiselle has taken to nesting in agricultural areas, including fields. This last circumstance gives hope that in Kazakhstan the Demoiselle will continue to live in cultivated areas, as it does now in many parts of Mongolia.

Unfortunately, we know still so little about the population and distribution of the Demoiselle in Kazakhstan and Central Asia that we cannot yet attempt even an approximation of its quantitative status. The research planned for 1981-1985 should provide an answer to such questions and concrete measures for improving the status of the Demoiselle.

Footnote: This paper has been translated for the International Crane Foundation by Elizabeth C. Anderson.

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SOME DATA ON THE DISTRIBUTION AND HABITAT OF THE DEMOISELLE CRANE IN MONGOLIA

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ABSTRACT

The author reports his observations of Demoiselle Cranes (*Anthropoides virgo*) in Mongolia, including information on the autumn migration in the area of "East-Gobi ajmak." Based on nests and pairs with young, the breeding habitat in the Chentej and Changaj-Mountains is described. Contrary to previous reports the Demoiselle Crane may build a nest of its own in wet meadows.

INTRODUCTION

From 26 August - 6 September 1977 and 2-26 June 1978, I participated in expeditions in Mongolia. Here, I present a brief report on information on the Demoiselle Crane (*Anthropoides virgo*) obtained during the two expeditions.

The Demoiselle Crane occurs in the Eurasian dry steppe-semidesert zone, extending from the Black Sea to the Great Chingan chain bordering Manchuria from the west. Smaller populations occur also in Tunisia and Morocco. It is a common and characteristic bird throughout much of Mongolia, occurring at every appropriate habitat, including the zones of the mountain forest-steppe, and in the semidesert zone with large lakes.

In 1977, I was in the districts of Tshoir and Sajn-Sand, to the south of Ulan Bator, then in the vicinity of Mandal north of Ulan Bator. Both Tshoir and Sajn-Sand are at the border of the steppe-semidesert zone. In 1978, we touched again the district of Mandal north of Ulan Bator. Then, we made ornithological observations in the Changaj Mountains in the Bajan Obo-Galut-Mandal area, starting from Bajan-Hongor. Our next camp was at the lake Bon Cagan-nuur in the semidesert zone where we spent a week.

MIGRATION

According to the literature, the Demoiselle Crane returns to its Mongolian nesting habitat in April. At the great lakes (Char-us-nuur) in west Mongolia, the first individuals were observed on 7 April in 1973 (Piechocki et al. 1981). In the Ulan Bator district the first cranes were reported to appear around 20 April (Kozlova 1932).

When the young are able to fly, families begin to flock as early as the end of July. It is not unusual, however, to observe solitary pairs or families of 4 members even at the end of August at the time cranes are departing (Bankovics et al. 1980). Non-breeding birds flock even during the nesting period. On 5 June 1978, for example, we observed after 1900hrs a loose flock of 40 birds in the vicinity of Bajan Obo, near the springs on the barren plateau in the southern part of the Changaj Mountains. In the evening cranes concentrated there, probably to drink.

In 1977, the autumn migration of Demoiselle Cranes started in the last days of August. While before 26 August there were crane groups of two to four scattered on the steppes, no Demoiselle Cranes could be seen at the same sites after 3 September. The first migrating flocks were noticed at Tshoir on 29 August; 60 birds flew over our camp from north to south in the course of the day. On 31 August and 2 September flocks were seen to land at Sajn-Sand, south of Tshoir. Within 5-6km south of the town Demoiselle Cranes were in dense flocks at the shallow salt lakes near several waders, including *Limosa limosa*, *Numenius minutus*, *Tringa glareola*, *Tringa terek*, etc. On 31 August and 2 September, there were 80 and 86 birds respectively on the lakes and another flock of 50 flew over without landing. In the northern part of the country, along the rivers Selenga and Orchon, crane migration also begins at the end of August (Piechocki 1968).

NESTING

According to the literature, the nesting starts at the end of May (Kozlova 1932). Based on personal observations, in the district of the Chentej Mountains, hatching starts at the end of May. It is consistent with the observation of 10 days old juveniles led by adults on 15 June. The incubation period lasts 27-28 days.

On 2 June 1978 I discovered a nest with two eggs in the valley of the river Chara, near the town of Mandal, north of Ulan Bator. The wide, treeless valley was characterized by dry grassy pastures along the river. But in some deeper areas that were inundated in spring, there were swampy spots with meadow and marshy vegetation. The nest was found in such an area, in the heart of a small, swampy islet surrounded by water 30-35cm deep. The flat nest was of reddish-brown dried moss. Its outer diameter was 62x65cm, the inside was 27x27cm. The eggs were warm. Their measurements were: 91x57mm and 91x58mm, respectively. At my approach, the two adults slowly left the nest. Meanwhile, 2 or 3 lapwings dived at the birds. For a while, the cranes warded off the attacks by leaning forward or flattening down, but later they flew off and settled at a distance of around 100m. The attack by the lapwings may suggest that cranes occasionally take their nestlings.

The discovery of the nest provides evidence that Demoiselle Cranes breed in marshy-meadow habitat.

AN EXAMINATION OF THE BREEDING ECOLOGY OF THE BLACK-NECKED CRANE

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ABSTRACT

The Black-necked Crane (*Grus nigricollis*) uses three types of nesting habitat: marshes, lake shores and stream sand bars. Marshes are the most important of these. In Qinghai Province the Black-necked Crane reproduces in May and June. Two eggs are usually laid at an interval of one to three days. The incubation period is 31 to 33 days. Both male and female share in nest-building, incubating and feeding of the young. In October the cranes leave Qinghai to winter further south and return the following March.

INTRODUCTION

The Black-necked Crane (*Grus nigricollis*) is one of the rare birds unique to our country. As far as the reproductive ecology of this crane is concerned, there are some fragmentary materials by Baker (1929), the Chinese Academy of Science's Zoological Research Institute and other units, and Ali (1976), but a detailed report has yet to be made. From June to August 1978, we carried out a selective study,focusing on the reproductive ecology of the Black-necked Crane at Longbaotan in Yushu County (Xian), Qinghai Province. From April to June 1979, we went back to this same area for further observations.

Qinghai Province is situated in the northeast of the Qinghai-Tibetan Plateau. Most of the province is 3000m above sea level, and more than four-fifths of the area is plateau. The Bayan Kara Mountains near the southern part of the province divide the watersheds of the Yellow and Yangtze Rivers. For this reason the drainage patterns in the province are very irregular with lakes and marshes scattered everywhere.

The climate of Qinghai Province is dry and cold. In January the average temperature is -8°C, reaching -20°C in the West. In July the average temperature is between 0°C and 20°C. The average yearly rainfall is under 300 millimeters.

DISTRIBUTION

The Black-necked Crane is distributed rather widely across Qinghai Province. Its tracks can be found everywhere in marshes, along lake shores, or on river sand bars. According to our study the major areas of concentration are in Zeku (Tse-k'u) in Huangnanzhou (Huang-nan-chou), about 100 miles south of Xining (Hsi-ning), in the Honan Mongolian

Autonomous County, about 30 miles south of Zeku, Gongho (Kung-ho), Guide (Kuei-te), and Qinghai Lake in Hainanzhou (Hai-nan-chou), a large region stretching south from Qinghai Lake (Koko Nor), Gangcha (Kang-ch'a), Qilian (Ch'i-lien) and Menyuan (Men-yuan) in Haibeizhou (Hai-pei-chou), a large region stretching north from Qinghai Lake, Dulan (Tulan), Niaolan (Niao-lan), Goermu (Ko-erh-mu) and Tianjun (T'ien-chun) in Haixizhou (Hai-hsi-chou), a large region stretching west from Qinghai Lake, Yushu (Yu-shu), Qumalai (Chu-ma-lai), Zhiduo (Chih-to) and Chengduo (Ch'eng-to) in Yushuzhou (Yu-shu-chou), a large region in central Qinghai Province, Maduo (Ma-to), Jiuzhi (Chiu-chih) and in Guoluozhou (Kuo-lo-chou), a large region in southeast Qinghai Province. The major breeding areas are Longbaotan in Yushu, Lake Zhaling (Cha-ling) near Maduo, Nuomuhong near Dulan, Muli near Gangcha, Shule (Shu-le) near Qilian, and the Zha (Cha) River and Kouqian (K'ou-ch'ien) River near Zhiduo.

NESTING HABITAT

The Black-necked Crane is a wading bird that nests in marshes, lakes, and along rivers. These areas with a moist climate, fertile soil, plentiful vegetation, and abundant wetland fauna provide good conditions for the Black-necked Crane to nest, find food, reproduce, and obtain protective shelter. Among the plants present are *Phragmites communis*, *Carex*, and *Eleocharis*. Wetland fauna includes arthropods and fish, and other waterfowl such as *Anser indicus*, *Tadorna ferruginea*, *Tringa totanus*, *Sterna hirundo*, *Mergus merganser*, *Fulica atra*, and *Podiceps cristatus*. According to our observations the primary breeding grounds of the Black-necked Crane are in marshy areas, such as the reed marshes of Nuomuhong in Haixizhou and the grassy marshes of Longbaotan near Yushu.

Longbaotan lies 4200m above sea level and has an extremely variable climate. In May and June temperatures can vary between 19°C and -12°C. The average temperature is about 5°C. The average relative humidity is 55 percent. Wind velocities of up to 13m/sec. have been recorded, the average is 4m/sec. Longbaotan is a long narrow high mountain grassy marsh running east to west. Scattéred across it are fresh water ponds. The ponds contain grass mounds of varying sizes that have been made into little 'islands' by the cutting action of the water. Some of the grass mounds are relatively soft, like a grass lawn floating on the water surface. The distance between them varies, and the depth of the water varies, too, reaching two meters in places. The bottom of the lake consists of a very deep layer of silt.

BEHAVIOUR

Activity

In March when the Black-necked Cranes migrate to Qinghai Province from the South they engage in group activity. At least 5 or 6 and as many as 20 or more will act together. On 16 April 1979 we observed one flock of 36 birds, but that was relatively large. It is during the time of flocking that the cranes create the conditions necessary for reproduction, namely, the finding of a place with food, a nesting area, and a mate. At the same time they also protect the healthy growth of the younger birds. Flocks arriving in March and departing in October flew in neat line or V formations. At this time they were also calling frequently. The males were larger with a thicker body, the females were smaller, thinner and longer.

In April and mid-May 1979 we observed flocking every morning and evening. The number of flocks and the number of cranes in each flock varied. Sometimes there was only one flock, sometimes two or three. In midday or during the afternoon there was less flocking. At times when the weather was changing (high winds or heavy snow falls), we frequently saw 20, 30 or more cranes banding together. Some were feeding, others preening, others looking around in all directions and some had placed their head under a wing and were standing on one foot with the other folded into the feathers on their belly as if resting. Occasionally we observed cranes 'playing' with *Sterna hirundo* or domesticated dogs. When a disturbance occurred those cranes standing watch immediately started calling out 'guoguo --- guoguo ---.' The other cranes then would take up the call, and they would all take to the air. Shortly they would settle again in a different place. As the cranes took flight their movements were rather slow. Their heads and necks were stretched out in front, the legs extended backwards and the wings flapped lightly. They appeared very sturdy but graceful, and looked very beautiful as they flew.

After the onset of the breeding season very little flocking occurred. The cranes formed pairs and stayed in the area where they would build their nest. During the incubation period one sat on the eggs while the other searched for food. Cranes of different pairs were sometimes seen to interact as they were searching for food.

Nests of *Tringa totanus* and *Anser indicus* were found in the vicinity of crane nests. These birds do not interfere with one another as they incubate their eggs and search for food. During the breeding season the Black-necked Crane usually remains within an area radiating 200-300m from the nest.

During the breeding season, we often observed a flock of about ten cranes, especially in the morning and evening. One of the cranes in the flock had red on the top of its head. The feathers on its breast were black while at the back of the neck they were gray. The feathers on the body were gray and the wings black-brown. It was slightly smaller than an adult and the irises in its eyes were yellow. We thought that all of these birds were young Black-necked Cranes. They frequently moved about the nesting area from mid-April to the end of May. After the middle of June we did not see this flock of young birds again.

Black-necked Cranes are very alert. During the breeding season we very carefully concealed thermometers in two nests, burying them in the grass between the two eggs. After two or three days we went to check and found that the thermometers had been thrown out and broken by the cranes. The cranes are shy and difficult to approach. When frightened they fly off at low altitude.

Feeding

Black-necked Cranes can be seen feeding every day from dawn until dusk. Mostly, they use their bills to pick up food from the ground or the water. Very rarely they use their feet to grasp food. If feeding in a flock they move about in a set area. If they stray too far from the flock in their search for food, they will fly back after a while. Pairs often search for food side by side.

In June 1978 we found fragments of green plants in the stomach of a female and in May 1979 the stomach of a male contained *Potentilla anserina*, small stones and pebbles.

Sexual Activity

During the breeding season sexual activity takes place mostly in the morning. If there is a change in the weather or the environment is disturbed, sexual activity will abate or stop. Sexual activities continue until after the second egg is laid.

On 20 April 1979, at 7:40 a.m. we observed a female emit a low 'gu--- gu---' mating call. At the same time both the female and the male pointed their bills and necks upward and with their wings outstretched engaged in a mating dance. The male then quickly mounted the back of the female, flapping his wings, the tails of the birds came together, and mating was achieved in a few seconds. After mating the male jumped off the back of the female and they both called out 'guoguo--- guoguo---' in a loud clear voice. When Black-necked Cranes are mating the male does not use his bill to hold the head or neck of the female. Both legs of the female bend slightly. Here it was discovered that the signal and behaviour signs to mate came first from the female and that this initiated the male's sexual reaction, and the consummation of mating. When the female was not ready there was no sexual activity.

The afternoon of 16 May 1979 was the last time we observed a female crane calling 'gu---gu---' and spreading its wings. The male, however, did not react at all. He was unable to mate, indicating that the mating season was over.

Breeding

Nest building. The nests are constructed in marshy areas where man and domestic animals cannot easily reach them. Most nests are built on dirt 'islands' or on grass mounds. These mounds often rise a little out of the water, either because they are on slightly higher ground, or because the grass is relatively thick. The nests are round or oval. They vary in size from 460-1240mm (external diameter)and 210-600mm (internal diameter). The outside is raised up to 160mm. The depression inside is 30-60mm deep and there is no cushioning material. The nest is formed by piling up dried *Carex*, *Eleocharis*, and other grasses found in the vicinity. Both bill and feet are used for this. The construction of some nests is very neat, others are rather flimsy. The distance between nests varies from about 500-2000m.

The Black-necked Crane builds its nest even as it is laying eggs and continues with construction of the nest right up to the middle of the incubation period.

Egg laying period. On 3 June 1978, we found the first nest at Longbaotan. It had two eggs. On 13 June, we discovered another nest with one egg. Two days later we found two eggs. In 1979, the first nest with eggs was found on 1 May, and the last one on 8 June. Most nests had two eggs that had been laid with an interval of one to three days. In 1979, we found seven active nests and one abandoned nest. There was some variation in egg size. The 17 eggs measured varied in length from 99 to 115mm (average 105.85mm), in width from 60 to 66mm (average 63.14mm). The average weight for 15 eggs was 217.70mg with a variation from 20.0 to 24.5mg.

The colour of the egg changed with the progress of incubation. Newly laid eggs were pale green with irregular brown spots scattered all over. The spots were especially dense on the blunt end. After some incubating the colour slowly darkened, changing from pale green to pale brown. The spots changed from brown to dark brown and extended around the center of the egg.

Incubation begins after the first egg is laid, with the female and male taking turns. At the change-over the arriving bird rearranges some of the grass with its bill. Then it bends its knees, puts its breast in contact with the egg(s), lowers its abdomen onto the nest, and begins incubating. Cranes sitting on a nest face into the wind.

According to observations made in June 1978 and May 1979 the incubation time for male and female differs markedly. At a nest observed in June 1978 the female was incubating for 61.8 percent of the time, the male for only 38.2 percent. At a nest observed in 1979 the daylight incubating time of the female also exceeded that of the male. Their incubating hours, however, were irregular. The number of exchanges varied from a low of two or three per day to as many as seven or eight. The incubation period lasted from 31 to 33 days.

During the incubation period we found an abandoned nest with one cracked egg some six or seven meters from one of the nests.

Fledging. According to our observations it takes about one day from the time an egg is pierced until the young bird emerges. On the day before the bird emerges, a small hole about the size of a bean is made at the egg's blunt end. It is gradually enlarged until the young bird's bill, head, and even the shoulders are visible. A 'ji ji' sound can also be heard. On the second day the shell is broken and the young bird emerges covered with moist brown down. The bill is red, but pale, almost white at the tip. The feet are grayish-red. The chick opens its eyes as it leaves the shell.

The abdomen of the young bird is extended. At first it cannot stand steadily. By the second day it is able to stand and moves about close to the nest. On the third day it begins to eat. Measurements of young cranes are given in *Table 1.*

Table 1. Measurements of eight newly-hatched crane chicks.

Weight (mg)	Bill Length (mm)	Toe Length (mm)	Body Length (mm)	Wing Length (mm)
118.13 (105-135)	21.88 (21-24)	45.69 (43-48)	199.88 (170-249)	30.08 (27-38)

During two years of observation we did not find one egg that failed to hatch in undisturbed nests.

The chick does not start feeding immediately after hatching. As a result its weight declines. In one nest we weighed the chick five days after it had hatched and found that its weight had declined by 8mg. Body weight gradually increased once the chicks started to feed. By this time the parents were leading the chick around the sandy and grassy shallows near the nest. The chick copied the food searching behaviour of its parents and pecked with its bill at food presented by them.

A week later the parents took the young crane to a safe area where food was plentiful. The young chick began to search for food for itself, and its parents also found food for it.

From the second day after hatching the parents led the chick away from the nest if they were disturbed or frightened and did not return.

Hand reared chicks. Hand reared chicks start fighting fiercely from the first or second day after hatching and unless they are separated they continue to fight until one of them dies.

When the young cranes were a month old they were able to catch small insects such as *Musca* and *Lucilia*. After two months they ate cooked rice, green vegetables, and egg yolks. Later the animal portion of their diet was increased to 80-90 percent with things like beef, mutton, small fish and small worms. After feeding on animal matter the cranes did not like vegetable foods any more. Only when very hungry would they take a small amount.

The weight of young cranes increases fastest when they are between 30 and 90 days old. Their average daily weight gain is between 74.3 and 100mg. After six months, if there has been no change in feeding patterns, body weight begins to decline at an average rate of 14.1mg/day. A month later body weight will again start to gradually increase at an average daily rate of 5.8mg.

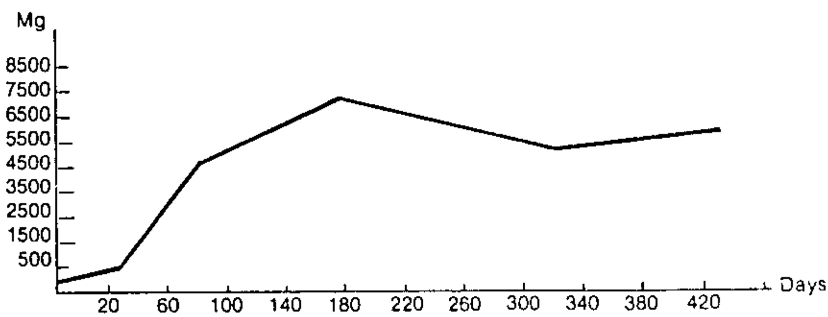

Fig. 1. Increase of body weight in hand reared chicks of Black-necked Cranes.

When the chick is 20 days old the colour of its head and tail becomes darker. At 28 days the quills of the primary feathers appear, the toes become grayish brown, the top of the head becomes pale yellow, and the ear feathers stick out. At 70 days the top of the head is yellow brown and the feathers on the abdomen are gray. At 90 days the flying feathers are fully grown. The primaries and secondaries are black. The feathers on the back are grayish yellow. On the neck black and white feathers alternate. At 240 days the irises are yellow brown and about one third of the neck is grayish black. Some yellowish brown feathers remain on the back. At one year the bird looks like an adult.

Density

Statistics derived from on-the-spot visual estimations made at Longbaotan in June 1978 and May and June 1979 reveal average crane densities varying from 0.78 to 0.76 birds/km^2.

From mid-April to the first ten days of May the average density was as much as 1.45 birds/km^2. This indicates that prior to the reproductive season when the cranes establish their nesting areas, their number is relatively high, exceeding the carrying capacity of the nesting area. This leads to competition and the final achievement of a relatively appropriate density. Thus, the average density in June was 0.76 birds/km^2.

Natural Enemies and Parasites

On 11 May 1979 we observed a Buzzard (*Buteo buteo*) flying over and then landing within 30m of a nest on which a crane was incubating. The other crane was searching for food nearby and when it saw the Buzzard it immediately flew back, spread its wings, stretched out its neck and bill, and rushed at the intruder, striking out with its legs and claws until it left the nest area. On 4 June we saw a Steppe Eagle (*Aquila rapax*) circling low over a nest. At times it dived down. When it saw us it immediately flew away. Similar observations were made in 1978.

Black-necked Cranes are infected by a number of internal parasites. On 21 June 1978 we dissected a female Black-necked Crane and discovered in its duodenum 24 *Echinostoma* that had caused catarrhs on the mucous membranes.

CONCLUSION

The range of the Black-necked Crane is narrow, its numbers and its reproductive power is low. It is now one of the animals receiving the highest level of protection in our country. We hope that the research units involved will carry out further research on the Black-necked Crane. We suggest that the responsible departments determine the necessary protective measures and strictly forbid the capture and hunting of these birds. We propose that natural refuges be established in those areas where large numbers of Black-necked Cranes live and reproduce.

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OBSERVATIONS ON THE WINTERING HABITAT OF THE BLACK-NECKED CRANE

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ABSTRACT

In China, the Black-necked Crane (*Grus nigricollis*) breeds on the Qinghai Plateau. In 1979, it was discovered to winter in the Sea of Grass in Weining County, Guizhou Province. Some 70-80 Black-necked Cranes and 800-900 Common Cranes (*G. grus*) were found there in December 1979. Recommendations are made for protection of the cranes and their habitat.

INTRODUCTION

The Black-necked Crane (*Grus nigricollis*) has its primary wintering and breeding areas in China. It is a rare species, listed in the first grade of birds under national conservation; its population is small and its distribution limited.

It breeds mainly in and around grassy marshlands, and highland lakes on the Qinghai (Chinghai) Plateau. On 29 November 1979, it was discovered that the Black-necked Crane, also winters in the Sea of Grass in Weining County, Guizhou Province (Kweicho Province). A survey was accordingly conducted, the findings of which follow.

NATURAL ENVIRONMENT

The Sea of Grass was once a great lake situated west of the county seat of Weining County in the eastern part of the Yun Gui Plateau (Yun Kwei Plateau). Its longitude is 104′14″ east and latitude 26′5″ north. It is the largest fresh water lake in Guizhou Province, being 45km^2 in area and 2200m above sea level.

Distant mountain peaks, once covered by forests of pine and fir, surrounded the Sea of Grass, and the emerald waters of the lake were once encircled by lush green trees, winning it the poetic name of Pine-Wave Lake. In the lake itself water plants stretched as far as the eye could see, hence the name Sea of Grass.

Today the features of the Sea of Grass have altered drastically. The forests have all been leveled, the waters of the lake drained, and the mountains, stripped of their forests, have become barren. Serious damage has been done to the environment. What remains of the Sea of Grass today lies in the western section of the former big lake. It has a mere 1.2km^2 of open water and a depth of only 20-50cm. Around the lake are marshes, the largest of which is to the southwest, while encircling the marshes are the wetlands, those to the southeast of the open water being the largest. Stretching outwards from the wetlands to the original reaches of the lake is an area that has been put to the plow (*Fig. 1*).

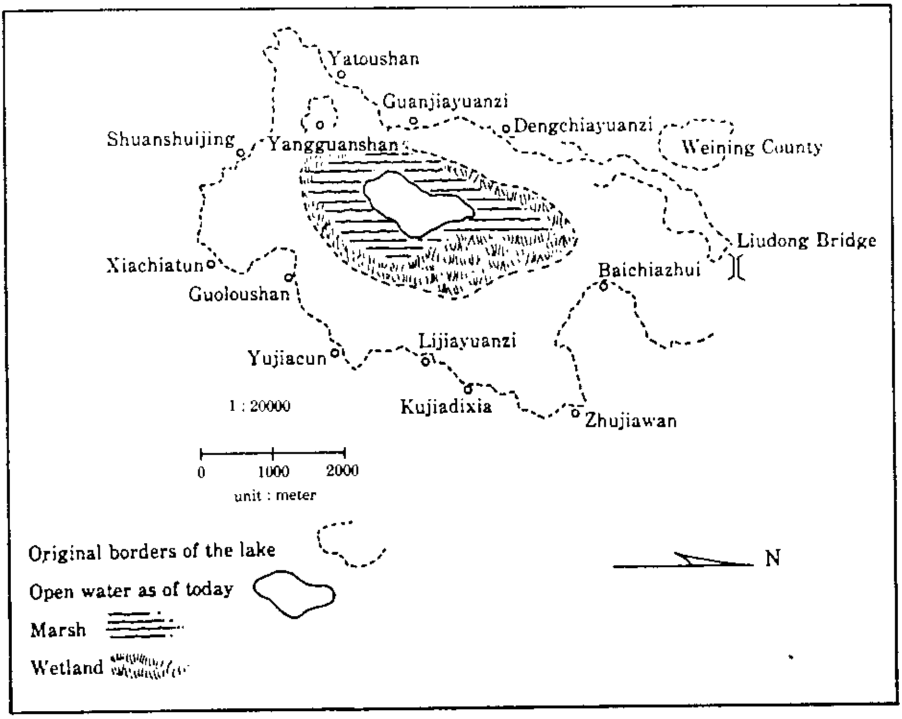

Fig. 1. The Sea of Grass and vicinity.

As a result of these changes the numbers of Black-necked Cranes wintering in the Sea of Grass have declined, proving that the conservation of the cranes involves not only the preservation of the species itself, but also that of its habitat.

HABITS AND BEHAVIOUR

The Black-necked Crane, better known to the local people as 'blackhead,' 'chailao,' or 'yan-e,' winters in Weining County's Sea of Grass, arriving in October and leaving in March.

In the Sea of Grass winters another species of cranes — the Common Crane (*Grus grus*). Its population is far larger. The Black-necked Crane has been found to mingle with the Common Crane. Although the two live together in mixed flocks, the Black-necked Cranes, relatively speaking, tend to keep to themselves. They do not wander off and lose themselves among the Commons.

When wintering in the Sea of Grass, the Black-necked Crane selects as its primary habitat the marshlands, which are near the water and have a profusion of tall cattails and other lush waterplants. It will also seek shelter in the cultivated fields on the outskirts of the marshes if and when it is continuously disturbed or alarmed.

The home range of the Black-necked Crane is to the southwest of the remaining open water, an area between Yangshanguan (Yangshankuan), Guoluoshan (Kuoloushan) and Zhujiawan (Chuchiawan). This is a wide stretch of marshy wetland that provides cranes with the right kind of habitat. At the same time, the area is almost free from human disturbances, making it ideal for the cranes to roost. Here, large patches of crushed grass, bird droppings and shed feathers have been found. The authors succeeded in getting close to the flock before daybreak. They observed the flight pattern of the birds in early morning and heard their cries at dawn. In the area northeast of the open water, between the county seat of Weining, Yangshanguan (Yangshankuan), Dengjiayuanzi (Tengchiayuantse), Guanjiayuanzi (Kuanchiayuantse) and Yangtoushan, the Black-necked Crane is rarely seen although this area, too, is marshy wetland. The reason for this is that the wetlands there are smaller in size, closer to populated areas, and subject to greater disturbances.

The daily behaviour patterns of the Black-necked Crane is similar to that of the Common Crane. It starts off at 700 when dawn is just breaking. Individual cranes lead off with a few solitary cries. The climax comes when the whole flock joins in. The cries of the cranes can be heard miles off. At 720 the cranes take to flight, leaving their roost for other parts. By 740 the sun is up and the sky seems full of these cranes, crying and wheeling around. Then they fly away, either as a large group or spread out in a line, extending at times well over 1000m. Between 800 and 1000 comes the first climax of the day in the cranes' behaviour, for the cranes are now exceptionally active, chasing or fighting one another as they feed. After 1000 the excitement gradually dies down. Noon to 1400 is basically the cranes' siesta time. From 1500 to 1600 the cranes feed again, coming to the second climax of the day at 1700. The cranes are now crowded together and the show they put on excels that of the first in splendour. Sunset is at 1800. Generally, if the cranes are not disturbed at this time, they will not go far. At 1900, when it is completely dark, the flock becomes quiet and the day's activities are over.

POPULATION OF THE CRANES

During 3-12 December 1979, through direct observation and by counting the number of individual cranes in a flock, 17 counts were taken. All but one were taken on the ground.

Of the 17 counts taken, 9 were of mixed flocks of Black-necked and Common Cranes, 7 were of flocks of Common Cranes and 1 only was of a flock of three Black-necked Cranes. Flocks of Black-necked Cranes are only rarely seen while flocks of Common Cranes are regularly observed. The Common Cranes outnumber the Black-necked Cranes. In the Sea of Grass there is one relatively big flock of mixed Black-necked and Common cranes. According to counts taken on 11 and 12 December, there were about 600 birds in the flock each time it was observed. The number of Black-necked Cranes in this flock was 46 and 52 respectively, 7-8 percent of the total. Apart from this big flock, there are also several smaller flocks, the number of birds in each ranging from a dozen to several dozen to a hundred or so. The total number of cranes in these scattered flocks comes to 200-300. Of these, 20-30 are Black-necked Cranes. There are therefore 70-80 Black-necked Cranes and 800-900 Common Cranes wintering in the Sea of Grass. In the mixed flocks, the Black-necked Crane accounts for about 8% of the population. The number of birds for the 17 counts totaled 1863. Of this, 140 were Black-necked Cranes, 7.5 percent. These figures come close to the actual number of Black-necked Cranes wintering in the Sea of Grass.

The Black-necked Crane is very selective in its habitat, preferring marshes and wetlands even if it may be living in a mixed flock. Of eight observations made in marshland a total of 126 Black-necked Cranes were seen on six occasions. Of four observations in wetland only a total of 11 Black-necked Cranes were seen on three occasions. In cultivated land only Common Cranes were seen on three occasions.

These findings also show that the Black-necked Crane chooses the same habitat for breeding and wintering.

PROBLEMS AND PROPOSALS

The conservation of an endangered species is far from being achieved when only measures such as a ban on hunting or breeding in captivity are taken to protect it. Preservation of the habitat it depends on for survival is absolutely necessary. Once the habitat is destroyed, the consequences will be serious. Therefore preservation of the environment the species needs should be on a par with the conservation of the species itself.

Althouth the Black-necked Crane is listed in the first grade of birds under national conservation, poaching still occurs and there are instances of people killing the cranes by enticing them with food mixed with pesticides. This threatens the very existence of the cranes. It is, therefore, recommended that the departments concerned launch a campaign aimed at educating people on the Black-necked Crane, supplemented by strict administrative measures.

As the Province of Guizhou (Kweichou) has adopted a comprehensive plan for the restoration of the waters of the Sea of Grass, it is proposed that certain provisions be made with regard to the Black-necked Crane and, taking into consideration the demands of the Black-necked Crane on wintering habitats, certain areas of marshes and wetland be set aside as a reserve to enable the Black-necked Crane to continue to use the Sea of Grass as its wintering habitat. The marshes and wetlands should be far from populated areas, preferably in places where human activities are less in evidence.

The Sea of Grass, is one of the rare highland fresh-water lakes in China and has a particular importance of its own. The Sea of Grass is similar to the Bird Island on Lake Qinghai (Chinghai) as certain species of water birds occur here in relatively large numbers. Furthermore, a rare species of crane, the Black-necked Crane, winters in the Sea of Grass. It is therefore recommended that the Sea of Grass be set up as a national conservation area so that the Black-necked Crane be protected not only in its breeding habitat but also in its wintering habitat.

THE DISTRIBUTION AND STATUS OF THE BLACK-NECKED CRANE ON THE TIBETAN PLATEAU

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ABSTRACT

The Black-necked Crane (*Grus nigricollis*) population on the Tibetan Plateau probably numbers 200. A few additional pairs breed in Ladakh, India. In Tibet, the birds are commonest at alpine bog meadows and are less frequently found in marshlands bordering lakes and rivers. Distribution and nesting behaviour are described.

INTRODUCTION

Except for several pairs of Black-necked Cranes (*Grus nigricollis*) that nest in Ladakh, India, this species breeds exclusively on the Tibetan Plateau of China. It is a rare species in China.

In 1876 at Lake Kokonor, Qinghai Province, the Russian ornithologist, Prezevalsky, discovered and described for science the Black-necked Crane. Subsequently the species has been reported across the Tibetan Plateau (Beick 1927; Bangs and Petas 1928; Schafer 1939; Ludlow 1944; Ali 1946; Li & Wang 1979). To this day, however, little is known about this crane because it nests at high altitudes in swampy wilderness areas. Because of the scant information on the Black-necked Crane, conservationists in China and in other countries are concerned about its survival. During biological surveys across the Tibetan Plateau in recent years, the author and his colleagues collected some information on the density and the habitat requirements of the Black-necked Crane, which are reported in this paper.

DISTRIBUTION

The Black-necked Crane breeds at widely scattered locations across the Tibetan Plateau into southwest Kansa Province and northwest Szechwan. In winter, flocks are found in south-central Tibet, northwest Yunnan, and northwestern Guizhow Provinces. Outside of China, the species breeds in Ladakh, India and small numbers are reported to winter in Bhutan, Burma and Vietnam (Archibald 1981; Delacour 1927).

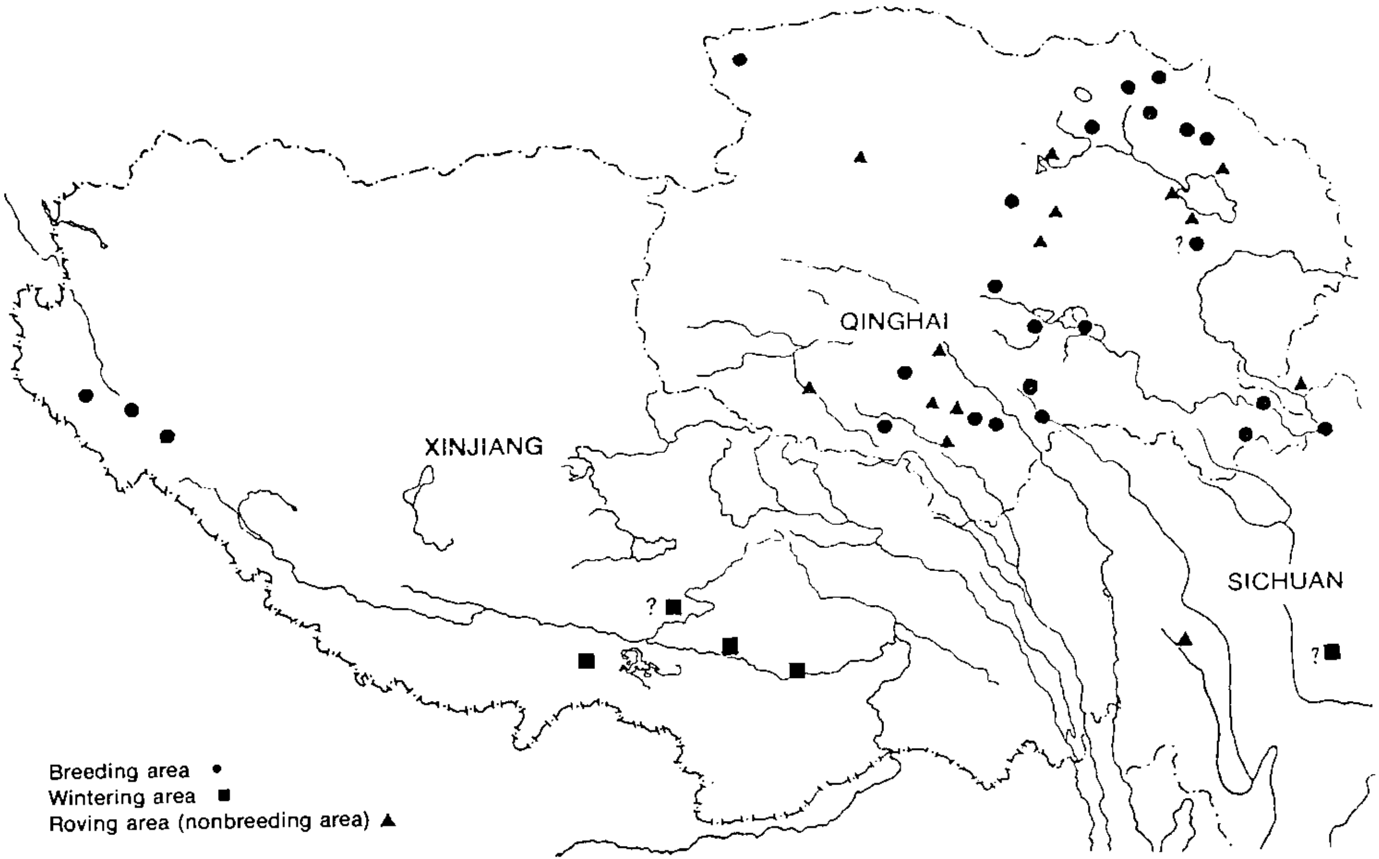

Fig. 1. A sketch map of distribution of Black-necked Crane.

Summer

The Black-necked Crane breeds in specific areas each spring; nonbreeding and wandering cranes are sometimes also found in these areas, as well as in other areas where the birds do not breed. In Baruun, Wutumairen, Saighai, and Shazhuyu the cranes spend the summer but do not breed. Breeding areas include Moyuntan, Longboutan, Huang Hee, Crooked Place, Qingshu Lake, Muli, and Alaer. In other regions, such as Lake Kokona, where these cranes once nested, they no longer breed.

At Longboutan, many cranes arrive in March, some remain to breed, while others continue on to other areas. Walton (1946) reported Black-necked Cranes breeding near Lhasa, but there is no proof of breeding in that area for the past 20 years. Likewise, Schafer (1938) found cranes breeding near Yaan, but now there are no Black-necked Cranes in that area.

Winter

In September and October, the cranes gather in flocks and migrate south to altitudes ranging from 2000 to 3000m. Today, Black-necked Cranes can be found wintering in Napahai in Yunnan Province (20 birds), Cao Hai in Guizhou (80 birds) and from Jiangzi to Lhagyari in Tibet (Guo Juting, 1981).

HABITAT

Saltwater lakes are abundant on the Tibetan Plateau, but Black-necked Cranes never frequent the shallows associated with them.

These cranes are found in three fresh water habitat types.

Alpine bog meadow

This is the most common and extensive wetland plant community on the Tibetan Plateau at about 4000m. These fresh water areas with an abundance of shallow water and vegetation are the ideal breeding habitats for the Black-necked Crane. Such remote areas are little visited by man and have a density of approximately 0.53 cranes/km^2 — the highest density of Black-necked Cranes for any type of habitat. The typical vegetation in these grassy marshlands include *Cobresia reyleana, Cobresia tibetica, Carex* spp., *Polygomum sibiricum, Primulailla amscrina* and *Taraxacum* spp.

Marshlands bordering lakes

Approximately 0.05 cranes/km^2 are found in this habitat, which borders such lakes as Noumahong Tengeli, Alaer Tiemulikei, Keilukei, and Sazhuyu. The vegetation includes predominately *Phragmites communis*, with lesser concentrations of *Typha angustifolia, Juncus gracillimus, Hippuris vulgaris, Chara fragilis* and *Potamogeon pectinatus.*

River bank marshes

The cranes are only occasionally seen in these marshes where the predominant vegetation includes *Clmnelymus nutans, Calamagrostris purpurea, Agropgron cristatum, Carex atrofusea, Reaumaria soongorica* and *Nitraria sibirica*. Cranes wintering in Tibet use the marshlands beside rivers and lakes.

BREEDING BIOLOGY

The cranes arrive in their nesting grounds in mid-March. They establish breeding territories, build nests,and lay their eggs. At Longboutan the distance between nests is usually 300m, but occasionally nests may be only 10m apart. Nests are constructed in either short or full vegetation on the marshlands. The nest is a simple platform. The eight nests measured averaged 88cm wide, 10cm tall, with a depression of 4.8cm in the center.

In ten nests surveyed, seven had two eggs and three had a single egg; the average egg weight was 209g, and average size 103.6x60mm. The eggs are greenish-gray or olive-gray in colour with rough spots of faint brown all over, more densely on the blunt end.

Both male and female incubate the eggs, but the female does most of the incubating through a period that lasts 30-33 days. Black-necked Crane chicks fight during their prefledging period, a behaviour that may result in less than 60 percent survival rate of the chicks hatched at Longboutan. The chicks remain with their parents all summer, then migrate south together in autumn.

CONCLUSION

The Black-necked Crane is an acutely endangered species. Its reproductive rate is low, the environment in which it lives is cold and bleak, and it may encounter as yet unknown problems on migration. This species deserves our utmost attention.

How many Black-necked Cranes remain on the Tibetan Plateau? Yao Jian-chu (1982) suggested 1000 birds in contrast to the former estimate of 100 or 200 (Gua Tuo Ting 1981). We concur with the latter estimate. For 20 years, we have surveyed the Tibetan Plateau. Our estimate of perhaps 200 birds on the breeding grounds agrees with the numbers at wintering areas. Consequently, the Government of the People's Republic of China has established laws to protect this species. Protected areas have been set aside and research has been expanded.

It is common knowledge that during the past three decades the people of the Tibetan Plateau have changed from a feudal society into a socialist society, and the natural face of the Plateau has been greatly altered. These changes do not directly effect the habitat of the Black-necked Cranes, for we have diligently surveyed all over the Tibetan Plateau. But the Black-necked Crane has become a very rare bird, perhaps from natural causes. Nonetheless, it is our very important task to conduct more research and to save the Black-necked Crane.

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FUTURE OF BLACK-NECKED CRANE IN THE INDIAN SUB-CONTINENT

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ABSTRACT

Approximately 7 pairs of Black-necked Cranes (*Grus nigricollis*) nest in Ladakh. Both in Kashmir and Bhutan, this species is under pressure because its scarce, high elevation habitat is being drained and settled. Protective measures, including a breeding programme, are proposed.

INTRODUCTION

Black-necked Cranes (*Grus nigricollis*) were found in Ladakh, northeastern Kashmir, as far back as 1923 (Osmaston 1925, Meinertzhagen 1927), but ornithologists were unable to find nests. Interest was revived in the 1970s when it became apparent that very little was known about the species and it had probably become very rare (Archibald & Oesting 1981). An expedition to investigate the status of the Black-necked Crane in Ladakh was therefore organized in 1976, under the leadership of Dr. Salim Ali.

The expedition could locate only two pairs of cranes, one of which was caring for a chick. The nest of the other pair had been robbed. The expedition recommended complete protection for the crane and its habitat, and suggested establishment of a high-altitude national park in Ladakh.

RECENT DATA FROM LADAKH

As a follow-up, I visited Ladakh again in 1978 and 1980. In 1978, I went there in late April to witness the arrival of the Black-necked Cranes from their wintering grounds, and to find evidence of breeding, if possible. My search resulted in the discovery of one nest near Chushul, the first concrete evidence of nesting within Indian limits. I stayed on for some days to observe the nesting behaviour.

In 1980, while confirming the occupation again of the breeding ground at Chushul, probably by the same pair, my investigations revealed another nesting site near Hanle, where a pair nested midstream in the shallow Hanle river. Another nesting pair was reliably reported from Lam Tso in the deep SW portion of Ladakh.

These investigations revealed that six or seven pairs of Black-necked Cranes migrate to Ladakh every spring. In the summer of 1982, seven pairs and three single birds were sighted in Ladakh. This is far more than what was found in 1976 and is even more than the number noted by British ornithologists in the 1920s.

Wintering Grounds:

Black-necked Cranes were first discovered wintering within Indian limits in the Apa Tani valley of Assam (now Arunachal Pradesh) by Betts in 1954. But subsequent investigations by Lavkumar in 1980 revealed that the cranes have stopped wintering in the Apa Tani, due perhaps to persecution by local tribals. He went on, however, to discover another wintering ground in the Boomthang Valley of Bhutan.

Lavkumar has made a number of useful recommendations for the protection of cranes and their habitat in Arunachal Pradesh and Bhutan (Lavkumar 1980).

When I visited Bhutan in 1981, I was able to observe 14 Black-necked Cranes wintering in Boomthang. I also found another valley, the Popshika, in central Bhutan, where 13 Black-necked Cranes were wintering. It can thus be seen that the territory of Bhutan is likely to be one of the major wintering sites of the Black-necked Crane. Further search is likely to reveal other places se far isolated and inaccessible, where these cranes winter.

Factors Affecting Status:

Though the number of Black-necked Cranes visiting the Indian subcontinent is by no means insignificant, their present condition and future prospects continue to cause concern. Factors affecting their existence in Ladakh in spring and summer are complex. Geological and geomorphological evidence exists to suggest that lakes and marshes in Ladakh are slowly drying up, thus contracting the breeding habitat of cranes and other birds.

In addition, local people use these marshes for grazing of their livestock, especially sheep and horses. Over recent years, the number of animals and men using these wetlands has increased, exerting pressure on the available space. Probably for this reason, breeding crane pairs have retreated to remoter areas exposed to greater risks. For example, the pair from Chushul no longer nests in a very favourable habitat, i.e. an excellent fresh-water marsh and lake to the west of Chushul where a nest was found robbed in 1976. The nest is now shifted to a remote little pool towards the east, an area surrounded by sand dunes and far less rich in plant and animal life than the lake to the west. Even here, the pair is disturbed by the movements of men and their animals.

Since 1976, the pair in Hanle has apparently not nested in the extensive marsh behind the Hanle Gompa, which used to be the traditional breeding habitat. With mounting pressure from men and their animals, it has probably foresaken this habitat for a totally unnatural one, nesting on a tiny island midstream in the Hanle river. The nest here was consequently exposed to greater risks, as is evident from the fact that in 1980 the nest was pilfered before it was put under constant vigilance by the Forest Department.

These disturbances are perhaps best reflected in the low survival rate of crane chicks: in 1976 between two pairs, one chick survived; in 1978 none of the chicks of the Chushul pair survived; and in 1980 again both the chicks of the Chushul pair perished, and only constant vigilance at the nest site enabled the Hanle pair to rear its lone chick to maturity.

Conditions in Bhutan:

Black-necked Cranes are exposed to less severe pressures on their wintering grounds in Bhutan. These areas are not open to visitors from outside. However, even in Boomthang, the roosting marsh reported by Lavkumar in 1980 was found to be drained in 1981. Consequently, Black-necked Cranes were not roosting in a flock but in family parties or little groups in suitable patches of bogs scattered throughout the valley. Popshika Valley is remoter and more inaccessible than the Boomthang and here the cranes were found to be comparatively tame and free from molestation.

RECOMMENDATIONS

The over all picture presented here seems to indicate the necessity of urgent corrective measures in Ladakh, both to arrest the deterioration in the habitat and to check the declining survival rate of chicks.

In the technical report submitted to the Government of Jammu and Kashmir, I had urged the adoption of a water management plan for the marshes. It is necessary that water levels be maintained and salinity of water checked in certain areas to foster growth of suitable plant and animal matter for use of wildlife throughout the breeding season. Lavkumar has recommended the cordoning off of some area by means of low stone walls to keep out grazing animals.

In the absence of such corrective measures, the cranes have shifted to areas where their nests and offspring are exposed to greater risks. Though the exact causes of death of crane chicks are not known, it appears that predators are taking a heavy toll, and parents have been unable to defend their chicks. If danger to eggs and chicks persists, cranes may abandon breeding areas in Ladakh and indeed, may stop coming to Ladakh altogether.

Inter-sibling rivalry among crane chicks generally results in the survival of only one chick out of the two that hatch. One of the eggs is, therefore, wasted in natural conditions. Removal of one egg from the clutch of two, does not adversely affect the nesting pair and may indeed improve the productivity of the wild flock as was evident among Whooping Cranes (*G. americana*) in the U.S. Dr. Archibald has suggested a similar experiment for Ladakh. It is perhaps not difficult to collect Black-neck eggs from the few nests already known. The real crux of the problem is where to transport them for artificial incubation, as modern facilities do not exist either in Ladakh or elsewhere in India.

While Dr. Archibald favours transporting eggs all the way to the International Crane Foundation, Baraboo, Wisconsin, USA, Indian scientists appear to be divided in their opinion. Dr. Salim Ali favours establishment of a breeding centre in Leh (pers. comm.). Lavkumar, on the other hand, fears that without trained personnel to man such a centre, the eggs should be transferred to the U.S., at least in the initial stages. Over the next few years personnel should be trained and facilities set up in India for the propagation of rare cranes. The chicks raised in Baraboo can then be brought back to the centre in India.

A breeding centre in Leh would not be easy to operate. Winters in Leh are very severe, with temperatures dropping to -20°C. Electric power needed to heat crane enclosures is not continuously available. For almost 8 months of the year, Leh is cut off from the rest of the country; the only means of communication remaining is by air. In emergencies, delay in the transport of food and/or medical help may prove fatal in such circumstances. Climate being uncongenial for a major part of the year, highly qualified persons may be unwilling to stay in Leh for long periods. A site at a lower altitude either in Kashmir or elsewhere in the Himalayas may be more suitable.

Some time may elapse before a suitable location is decided upon and necessary facilities set up. Until then, crane pairs should not be left to the mercy of the elements and their natural enemies. It is imperative that egg collection should begin very soon, and the eggs be initially transported to ICF. Simultaneously a search should begin for a suitable location in India and selection of staff made for training in crane management in the U.S.

The wintering population in Bhutan needs to be studied in greater detail. Boomthang and the adjacent Gyetsa valleys are well-settled and explored, but the remote Popshika valley encloses an extensive marshland that needs to be explored fully. The author could not explore the valley fully in 1981. At a height of 3000m, the marsh may prove a potential breeding ground for these cranes.

The future of the Black-necked Cranes in the Indian subcontinent is thus linked with the active management and study of their populaiton and of the habitat they prefer.

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NOTES ON THE BLACK-NECKED CRANE IN LADAKH

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The local name of the Black-necked Crane (*Grus nigricollis*) is 'Tung-Tung.' The species breeds only in the extreme east of Ladakh District, in a region known locally as Changthang, which is geographically and ecologically a part of the Tibetan plateau. It is a cold desert environment lying above 4000m, with constant winds and low annual temperature where water can still freeze in May. The birds arrive in Ladakh from the middle of April to the first week in May and they depart again in October or November.

The main food of the crane in Ladakh is the bulb of *Trigolochin palustoel*, a Juncacinaceae that is called 'Gerge' by the local people. It is common in the marshes where the cranes breed. In early spring, the cranes press their beaks through the shoots of this plant until they reach the bulbs, which are then pulled up and eaten. By the end of the summer, banks of discarded shoots of *Trigolochin palustoel* are piled up by the wind at the marsh edges. In addition, they eat small lizards, fish, aquatic insects, and shrimp (which are locally called 'Shabe Gyanis').

As well as feeding in marshes, the cranes are often seen roaming on dry ground and hilly areas, where the lizards are most common. At other times, they join the flocks of domestic sheep, goats and yaks grazing in areas where water insects are abundant.

In Ladakh the cranes prefer to nest in marshes with raised hummocks. Fresh water flows through these marshes to a depth of 0.4 to 0.6m. The marshes are surrounded by large areas of dry sandy plains and hills. Of the seven breeding pairs located, five nested on raised hummocks and two on large patches of marsh vegetation.

Table 1 outlines the location of the cranes between 25 May and 6 June 1982. For four of the pairs, eggs were not located at the time of the census but the cranes were reported to be there for the whole summer. The distance between pairs is about 60km.

Soon after arriving, the cranes perform their courtship dance. Both birds indulge in continuous head-bowing, leaping vertically in the air, and sometimes one bird circles the other. Instead of stick-throwing, as noted in other crane species, the Black-necked Crane throws pieces of house-dung (there are no sticks in Changthang). Then the birds run with wings outstretched after each other for up to 50m. Then they stop and start feeding together slowly.

Throughout Ladakh, but particularly in the Changthang area, the local people are Buddhists and the crane appears in Tibetan songs, folklore, religion and paintings. Consequently, the cranes are not molested. They are more respected than other birds, particularly because they dance, a sight that is cherished by the shepherds. The cranes are

Table 1. Nesting sites of the Black-necked Cranes in Ladakh in 1982.

Name of site	No. pairs seen	No. eggs seen	No. other cranes seen	Altitude (m)
Tsobok	1	2	3	4145
Chushul	1	2		4385
Lhungparma	1			
Fukche	1			
Hanley	1	2		4257
Tsokar	1			4534
Tsomoriri	1			4524
Total	7 pairs	6 eggs	3 cranes	

unafraid of the Ladakhis and, by joining the herds of domestic animals, they may escape predators such as the fox and wolf. The nesting areas also provide excellent grazing grounds for herds.

The Department of Wildlife Protection of Jammu and Kashmir, India, is keenly interested in the Black-necked Crane and will soon declare the nesting areas as game reserves. The World Wildlife Fund-India is also promoting conservation education to help this endangered crane. The Black-necked Crane is secure in Ladakh as it shares a remarkable ecosystem with Wild Ass, Tibetan Wolves, Alpine Hare, Red Fox, Hamsters, Ruddy Shelduck, Mongolian Sand Plovers, Horned Larks, Hume's Short-toed Larks, Ravens, Desert Wheatears, Brown-headed Gulls and Redshanks.

DISTRIBUTION OF THE RED-CROWNED CRANE IN NORTHEAST CHINA

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ABSTRACT

In April-August 1980, May-November 1981 and March-September 1982, investigations were carried out using jeeps and aircraft. The data indicate that the Red-crowned Crane is rare, reduced both in population numbers and range of distribution in northeast China. The present breeding area includes the lower reaches of the Hulin River and the Wuyur River and the Sanjiang (three river) lowland. The population of Red-crowned Cranes in the breeding area numbers approximately 500 birds.

INTRODUCTION

The Red-crowned Crane (*Grus japonensis*) is one of the typical migratory birds in China. The cranes return to the breeding grounds in family groups or pairs in early March, 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. Therefore, the breeding range of the Red-crowned Crane is relatively stable in northeast China.

CENSUS METHODS

Investigations of distribution and population of the Red-crowned Crane were carried out in 1979-1982. The survey of both banks of the Sungari River below Harbin and the lower reaches of the Heilongjiang River was carried out in motorboats. From 1979-1981, the total mileage was 1141km. On land a jeep was used; we have traveled 11,487km in the past three years. We used a 8x30 binocular telescope for direct observation in transect surveys. We divided the region around our field station into small areas and made repeated observations during our stay.

In late May we did an aerial survey of lower reaches of the Wuyuerhe River. This is late in the incubation period of the Red-crowned Crane; at that time the birds do not move far from their nest. We used a type Y-11 aircraft, which is a light twin engine short take-off and landing aircraft, with a good field of view and which is safe at ultralow altitude. The survey flight altitude was 80-120m and the air speed 150km/h. The birds were counted by four census workers along a 2km-wide transect (1km/side). The results were recorded on a map with transect mark lines; all transects were numbered. When there was any doubt about the statistics, the survey was repeated. After the survey was completed, we discussed the results immediately, eliminated what was duplicated and established the number of cranes in the area. Total aerial transects distance exceeded 2184km, the area covered was 209,000ha.

DISTRIBUTION AND POPULATION

In former times, Red-crowned Cranes were widely distributed in the wetlands and marshes of northeastern China. However, the conditions of their habitat has undergone changes, so that not only are their numbers greatly reduced, but also their range has shrunken. Our survey data show that the cranes are mainly distributed in the following ten nesting areas (*Fig. 1*).

Xianghai Nature Reserve: Located in Tongyu Xian in the western part of Jilin province, the Reserve covers an area of 106,660ha, of which 46,000ha is marsh. We have spotted 40 Red-crowned Cranes in the reserve 11 April-26 May 1980. In addition, Demoiselle Cranes (*Anthropoides virgo*), Common Cranes (*G. grus*), and White-naped Cranes (*Grus vipio*) breed in this area.

Banks of lower reach of Nenjiang River: At the convergence of the Nenjiang and Sungari Rivers the land is low and flat, with marshes distributed on both sides of the rivers. This was once a good breeding ground for the Red-crowned Crane. The construction of a water reservoir and the drainage of the marshes for crop growing in recent years has reduced the number of the cranes. In March 1980, we found 3-5 Red-crowned Cranes here.

Wuyuerhe River basin: The headwaters of the Wuyuerhe River are at the southwestern slope of the Xiaoxinganling Mountain (Lesser Khingan Mt.). The water drains into a big swamp, which forms an ideal habitat for waterfowl. The main part of it forms the Zalong Nature Reserve, covering an area of 42,000ha.

In 1980, we walked through the area and spotted about 200 cranes. In May 1981, an aerial survey of the area found 173 Red-crowned Cranes, among which were 22 young birds, 12.7 percent.

This is also a breeding site for the White-naped Cranes and Demoiselle Crane, and a staging area of the Siberian Crane (*Grus leucogeranus*).

Swamps along the Sungari River banks: On the northern bank of the Sungari River in Tonghe Xian, there is a small area of wetland and pools. There were two pairs of Red-crowned Cranes in July 1980, but no young birds were seen.

Lower reaches of Duluhe River: Located in Luobei Xian, the swamp occupies about 16,000ha; it is mainly a reed swamp. About 60 cranes were observed.

South bank of lower reaches of Heilongjiang River: In August 1982, we saw about ten cranes wandering on the wetland along the river banks in the Tongjiang Xian and Fuyuan Xian area. According to the fishermen, Red-crowned Cranes breed there.

Honghe River Nature Reserve: It occupies an area of 31,220ha in Tongjiang Xian of which 15,370ha are swamps. Breeding cranes totalled about 50. Whooper Swan (*Cygnus cygnus*) and Spoonbill (*Platalea leucorodia*) also breed here.

Qixinghe River basin: In the triangle formed between the converging Qixinghe and Raolihe rivers, a reed swamp occupies an area about 96,000ha. It has one of the larger populations of Red-crowned Cranes, estimated at 100-130 birds. There are also many other kinds of waterfowl. We have recommended to the government to make this area a nature reserve.

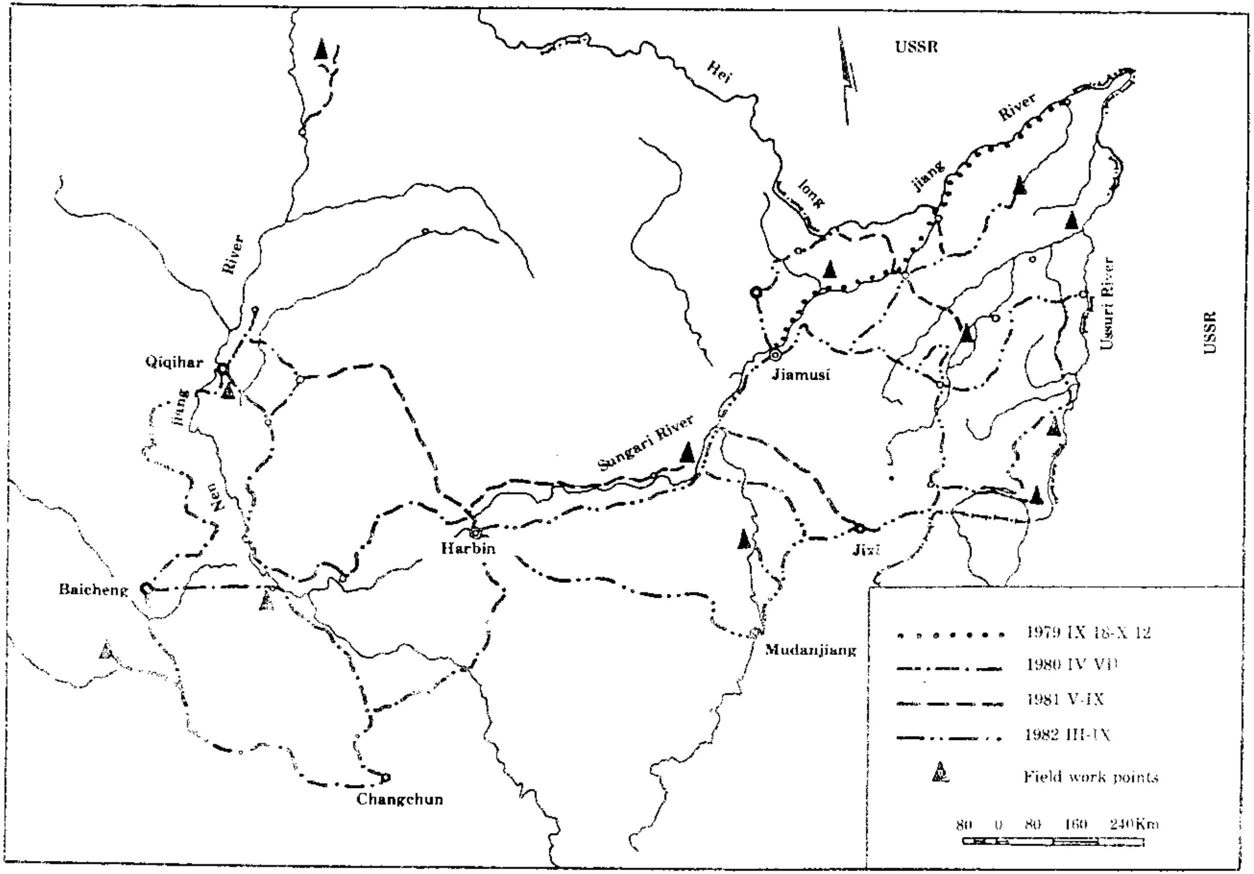

Fig. 1. The field survey routes and areas in 1979-1982.

The mouth of Raolihe River: In the Raohe Xian, where it joins the Ussuri River. Both sides of the river are low wide marshes formed by river floods. In July 1982 several pairs of Red-crowned Cranes were observed.

Xingkai Lake plain: On the northeastern side of the Xingkai Lake and on the banks of the Songachahe River, the land is low, marshes and wetland occupy an area of about 26,000ha. There are about 40-50 Red-crowned Cranes.

CONSERVATION

In recent years, the Red-crowned Crane has become rare. It is one of the first class protected birds in China, and is protected by law. In addition, we established the Zalong Nature Reserve (1979) and the Xianhai Nature Reserve (1981), and we have recommended that the government establish the Honghe, Qixinghe River and Xingkai Lake Nature Reserve.

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CRANES ON THE MIDDLE AND LOWER REACHES OF THE NENJIANG RIVER, THE PEOPLE'S REPUBLIC OF CHINA

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Five species of cranes have been found in the vast plains on the middle and lower reaches of the Nenjiang River in the northeast of China: Red-crowned Cranes (*Grus japonensis*), White-naped Cranes (*G. vipio*), Common Crane (*G. grus*), Hooded Crane (*G. monacha*), and Siberian Crane (*Grus leucogeranus*). The first three species are summer residents, the other two merely pass this area in migration.

Red-crowned Cranes usually arrive here in the middle of March. The earliest recorded arrival is 8 March 1975. Most nest in the reed swamps, but a few pairs breed in the grassy marshlands. They depart by the middle of November.

White-naped Cranes also arrive in the middle of March, at the same time as or a few days later than the Red-crowned Cranes. Most White-naped Cranes breed in the reed swamps. They usually leave in early November.

In late May 1975, we discovered 122 Red-crowned Cranes in Zhalong Natural Reserve on the lower reaches of the Wu Yu-er River, an area of 16,950ha. This is a population density of 7.2 birds/4ha. In the same area we discovered 34 White-naped Cranes, a population density of 2 birds/4ha.

Common Cranes arrive in the middle and lower reaches of the Nenjiang River at the end of March. Then they move about in flocks in the grassy marshlands, near the hillocks in marshes,or in the fields. In the early morning and towards evening they often join Hooded Cranes in mixed flocks of more than a hundred birds; sometimes a few White-naped Cranes join these groups. Occasionally they feed in the fields of newly sown maize and wheat. The largest flock of Common Cranes observed had 84 birds. Flocks remain to the end of May. We did not find any nests or eggs of Common Cranes on the middle and lower reaches of the Nenjiang River, but we did see young birds.

Hooded Cranes usually come to this area in early April, and remain until late May. During their stay, they mostly move about in flocks of up to 50 birds.

In late August Hooded Cranes return to this area and remain until early October when they fly south. During this time they usually form flocks larger than in spring, and they often feed on ripe maize. The largest flock of Hooded Cranes observed in autumn was about 150 birds.

Siberian Cranes are found in the reed swamps in the lower reaches of the Wu Yu-er River from the end of March to the end of May, during their spring migration. The largest groups observed were:

YEAR	DATE	MONTH	PLACE	NUMBER
1976	13	April	Zhalong	30
	17			66
1977	24	April	Lindian	50 or so
	24	May	Zhalong	24
1982	22	April	Lindian	33

During their stay here, Siberian Cranes often forage in the shallow swamps and wetlands, or near the hillocks and small lakes. They usually remain in the same area all spring, but they often visit different areas in different years. When the Siberian Cranes leave the lower reaches of the Wu Yu-er River to continue their migration, they fly northeast. Whether Siberian Cranes breed in northeast China is an important topic for further research.

THE CONSERVATION STATUS OF THE BREEDING GROUND OF THE RED-CROWNED CRANE IN HOKKAIDO, JAPAN

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ABSTRACT

The Red-crowned Crane (*Grus japonensis*) in Hokkaido, Japan, has decreased drastically this century because of human intrusion into its habitat. Although its numbers have actually increased from 30-300 during the past three decades, the future of this species in Japan is not assured. The recent increase is due to artificial feeding in winter, which has brought the population to saturation level in the breeding habitat. The protection of the breeding habitat is now the most important factor in protecting the species. It is difficult to estimate the security of each nesting area because both the government and many private parties own the land and their plans for it change. Many factors contribute to an optimal nesting habitat and well established pairs may continue to nest even when several of these are lacking. Each nesting area was ranked from 1 to 5 depending on the security of the habitat from development and its use by the cranes, and a forecast was calculated for the long-term survival of these habitats.

INTRODUCTION

There are two populations of the Red-crowned Crane (*Grus japonensis*) in the world. One is migratory and is found in southeastern Siberia and northern China during the breeding season and in Korea and southern China in winter. The other is sedentary and inhabits Hokkaido, Japan (Archibald 1972). During the International Crane Workshop, we discovered that the migratory population was about 700 to 800, much less than previously estimated, and the population in Japan was about 300. Both populations have decreased drastically during recent centuries due to impacts by man (Masatomi 1979, 1981b).

Until the 17th century, Hokkaido was inhabited exclusively by aboriginal people, the Ainu. They called the cranes "Sarurunkamui," God of the Marsh, and they lived peacefully with them. After the Japanese conquest, the cranes soon vanished from southwestern Hokkaido due to hunting and agricultural development of the marshes at the end of the 19th century. A small flock survived in eastern Hokkaido; the first nest of this group was found in 1926 (Saito 1926). Until recently, the cool climate in eastern Hokkaido delayed the development of the marshes into farmland, so that the present habitat has been the last refuge for the cranes in Japan.

Apparently limited by food supply in winter, the cranes maintained their population at about 20 to 40 birds until the early 1950s. When the streams in which the cranes fed froze over during the unusually cold winter of 1952, the local people scattered corn on the agricultural fields where the cranes searched for gleanings. At the same time, the crane was approved as a Special Natural Monument by the Japanese Government, thereby giving the birds utmost protection. The artificial feeding was continued each winter and the crane flock has increased to 300 birds over the past three decades (*Fig. 1*).

Although the population is still increasing, the cranes face various problems concerning the security of their breeding habitats. Despite the cranes' continued increase in numbers, the intense agricultural development on and near the breeding habitat gives great concern for their ultimate fate. This paper examines and evaluates the present environmental status of each breeding territory of the Red-crowned Crane in Hokkaido and outlines the proposed fate of each piece of real estate that constitutes a crane territory.

THE NESTING TERRITORIES

Listed on *Table 1* is each nesting territory. The location of each territory is shown on *Fig. 2 to 7*. In most cases each marsh used by nesting cranes is simply labelled in alphabetical order from west to east or south to north. Marshes that were former nesting grounds have two letters: the first indicates the marsh to the immediate west or east, the second is 'Z.' For example, PZ is a former breeding marsh and located west of marsh P. Marshes that have recently become or will possibly become nesting grounds also have two letters, the first indicating the marsh to the immediate west or east, the second being 'A' or 'B.' For example, OA is a newly found breeding ground and located east of marsh O. In each marsh, each nesting territory is numbered approximately from south to north. The combination of alphabet and the number describes each nesting territory. For example L6 is the sixth and most northern nesting territory in marsh L. For convenience, some territories have been given numbers at variance with this system.

Nesting status data in the whole area were collected from various sources. The first air survey was carried out in Kushiro and Nemuro districts by Archibald, Masatomi, and Kitagawa in 1972. The results of the survey confirmed that the cranes in Hokkaido do not migrate but breed on the remote marshes in Hokkaido. Therefore, an air survey was done of the entire breeding range by the Hokkaido Educational Committee in 1973, 1974, 1979, and 1980. Archibald and Masatomi flew over the marshes again in 1977. Only Kushiro district was surveyed by the Kushiro Educational Committee in 1978. Most of the data from before 1972 were taken from Masatomi (1974) and Inoue (1975, 1976). The International Crane Foundation-Japan surveyed most of the areas in 1981 and Masatomi did the same in 1982. Some data were provided the author by local people. *Table 2* shows the complete nesting status for the past two decades.

THE POPULATION CHANGE

Since 1952, an annual winter census of the Red-crowned Cranes has been carried out by the Hokkaido Educational Committee. Although there are various problems with the results, mentioned by Masatomi (1981a), the population trend is worthy of discussion (*Fig 1*). The rate of increase between 1952 and 1960 was about 23 percent/year, much higher than in the years after 1960. The crane population was probably limited by the quantity of natural food in winter before 1952, which explains the rapid and constant increase after the start of artificial feeding in 1952. However, since 1960 something has happened to abate the rapid increase. After 1960, crane mortality due to collision with power lines increased, especially in autumn and winter when cranes gathered at the feeding stations where power lines are more concentrated than on the marshes. Thousands of tourists visit the feeding stations to appreciate and photograph the birds. To photograph a crane in flight, impatient photographers would sometimes flush the cranes. In the resulting confusion, the cranes often flew into the high tension wires and died. Between 1962 and 1980, 2.1 percent of adults and 13.4 percent of chicks were killed by striking power lines. Recently, the crane

Table 1. Key to names of each marsh and each breeding territory of the red-crowned crane. E: east, Es: estuary, L: lake, M: marsh, N: north, P: pond, R: river, S: south, V: vicinity, W: west.

Code	Marsh	Code	Breeding territory
A	Toberi	A1	Toberi R Es
AA	Horokayanto	AA1	Horokayanto
B	Oikamanai	B1	Seika
C	Kimonto	C1	Kimonto N
		C2	Kimonto S
		C3	Kimonto Konuma
D	Yudo L	D1	Yudo L
		D2	Yudo R
DA	Chobushi L	DA1	Chobushi L
E	Tonkeshi	E1	Tonkeshi
EZ	Onbetsu	EZ1	Onbetsu
F	Koitoi	F1	Koitoi
G	Kushiro M	G1	Otanoshike
		G2	Tsuruno
		G3	Hokuto
		G4	Hokuto-Shindo E
		G5	Hokuto-Shindo W
		G6	Shimo-Ninishibetsu
		G7	Setsuri R Toya V
		G8	Sake-Masu Fukajo
		G9	Iwabokki-yama SW
		G10	Kushiro R SuimonV
		G11	Setsuri R Bunkiten V
		G12	Takkobu L
		G13	Oshima R
		G14	Akanuma V
		G15	On-nenai
		G16	Shimosetsuri
		G17	Hosooka
		G18	Toro-Futamata N
		G19	Toro-Futamata S
		G20	Kenechara R No. 1
		G21	Kenechara R No. 2
		G22	Kenechara R No. 3
		G23	Arekinai
		G24	Kirakotan
		G25	Miyajimazaki
		G26	Chiruwatsunai
		G27	Shimokuchoro S
		G28	Shimokuchoro N
		G29	Shirarutoro S
		G30	Kayanuma
		G31	Shirarutoroetoro
		G32	Kattaro
		G33	Kattaro-Kami
		G34	Numaoro
		G35	Numaoro-Kami
		G36	Ososhibetsu
		G37	Ososhibetsu-Kami
GZ	Onnebira	GZ1	Onnebira
H	Bekanbeushi R	H1	Bekanbeushi R Chanbetsu R Bunki V

Table 1. (continued)

Code	Marsh	Code	Breeding territory
		H2	Chanbetsu No. 1
		H3	Chanbetsu No. 2
		H4	Chanbetsu No. 3
		H5	Chanbetsu No. 4
		H6	Katamusari R
		H7	Fuppoushi
		H8	Chanbetsu No. 5
		H9	Sho-Bekanbeushi R
		H10	Takkaruushi R Karyu
		H11	Chu-Bekanbeushi R
		H12	Bekanbeushi R Es
		H13	Bekanbeushi R Tai-betsu R Goryuten
		H14	Itoizawa
		H15	Itoizawa E
		H16	Itoizawa W
I	Akkeshi	I1	Tokitai
		I2	Tobai R Es
J	Mochirippu	J1	Mochirippu L
K	Hichirippu	K1	Hichirippu S Konuma
		K2	Hichirippu E
		K3	Hichirippu W
		K4	Hichirippu N
L	Biwase M	L1	Biwase Ichiban R
		L2	Biwase R Es
		L3	Dei R
		L4	Rokuban R
		L5	Onnuma
		L6	Wakasa P
M	Poroto	M1	Poroto P
N	Esashito	N1	Esashito P
O	Fureshima	O1	Fureshima
OA	Baba	OA1	Baba
P	Tosanporo	P1	Tosanporo P
PA	Hikiusu	PA1	Hikiusu
PZ	Nokamappu	PZ1	Nokamappu
Q	Suido	Q1	Suido P
R	Onneto	R1	Onneto S
		R2	Onneto Nishi-Sanban R
		R3	Onneto N
S	Shunkunitai	S1	Shunkunitai E
		S2	Shunkunitai Kitsunemori
T	Furen L Konan	T1	Bettoga R
		T2	Kaigarakotan
		T3	Sosanbetsu
		T4	Yarimukashi
		T5	Betoga R W
U	Furen L	U1	Myogo
		U2	Furen R Joryu
		U3	Tonden R
		U4	Kimura R
		U5	Furen R E
		U6	Furen R Es
		U7	Anebetsu
		U8	Furen R Kami

Table 1 (continued)

Code	Marsh	Code	Breeding territory
		U9	Mumei R
V	Yaushubetsu	V1	Muniusu
		V2	Yaushubetsu R
		V3	Ponyaushubetsu R
W	Shikotan	W1	Ipponmatsu
		W2	Bochi
		W3	Tsuboi
X	Nishibetsu	X1	Kanekin
		X2	Seimarubetsu
		X3	Barasan L
		X4	Barasan R
Y	Notsuke	Y1	Ipponmatsu
		Y2	Bokko P
		Y3	Todowara
		Y4	Ekitarausu
		Y5	Pon-Nittai
Z	Chashikotsu	Z1	Tohoro R Es
		Z2	Chashikotsu R Es
ZA	Tofutsu	ZA1	Tofutsu L
ZB	Kunashiri Island	ZB1	Uennai
ZZ	Shibetsu R	ZZ1	Shibetsu R

numbers have begun to increase again. One reason for this is that yellow plastic pipes have been attached to power lines. These help the cranes see the wires, and the mortality from this source has declined. Another reason for the recent population increase might be the improvement in census techniques by using helicopters rather than just ground surveys. For example, in 1980, 19 birds not observed from the ground were counted from the helicopters (Hokkaido Educational Committee).

Although the worst period for collision with wires was between 1962 to 1966 and between 1967 and 1971, the number of the birds still increased by 6 percent (*Table 3*). Undoubtedly, the decline in mortality be collision with wires was a primary factor in the dramatic increase in the population after 1976, particularly since the productivity of the flock remained approximately constant at 13-14 percent from 1962 to the mid-1970s (*Table 4*). Constant productivity indicates an increasing number of breeding pairs in the increasing population. However, some of the nesting territories have been destroyed. Displaced pairs or new pairs may be more tolerant to nesting close to humans. During the air survey in 1981, two new nesting sites were found (V1 and V2 on *Fig. 6*). They were very close to each other and divided by a bridge that brought the new pairs much closer to human activities.

Another reason for the increase is that some birds have migrated from Hokkaido to colonize new nesting areas. Kunashiri Island (*Fig. 7*), which is located about 20km east of the eastern coast of Hokkaido had one nest in 1982 (ZB1). Suisho Island (*Fig. 5*) has extensive marshlands and is located less than 10km from the tip of Nemuro Peninsula. Cranes have been breeding near the tip of the peninsula every year for more than ten years. Therefore, it is possible that cranes may expand their breeding range to more Soviet islands. Tofutsu Lake in Abashiri, northeastern Hokkaido, (ZA1, *Fig. 8*), which has had five to eight birds for several years during the breeding season had the first successful breeding pair in 1982. This is also an example of the expansion to a completely new place.

It is clear that the traditional nesting areas in southeastern Hokkaido have reached a saturation level. Additional crane pairs must colonize new areas in northeastern Hokkaido or on the Soviet islands. There is evidence that some pairs are now attempting to nest on inferior marshes such as OA1 (*Fig. 5*), which had the first nest in 1981. This marsh is very

Table 2. Breeding status of each breeding territory between 1966 and 1982 on the red-crowned cranes, and the environmental evaluation of each breeding territory in 1980s and 1990s. N: nest, f: family, A: adult, SA: subadult, Br: incubating, e1(2): one (two) egg(s) on a nest, number on the upper right: number of (adult) cranes, number on the lower right: number of chicks, Y: yearling, EE: environmental evaluation, 1: pristine, 2: pristine but with adjacent problems, 3: on-site development, 4: almost completely destroyed, 5: habitat destroyed (cont'd.).

	A1	AA1	B1	C1	C2	C3	D1	D2	DA1	E1
before 1966							A^2 1948			
1966										
1967	N									
1968	N			←	N	→				A^2
1969	N									
1970	N									
1971	N						f^2_1			
1972	N									
1973	N				N^2					f^2_1
1974	N^2_{Br}			$N^2_{Br} \to A^2$	$N^2_{Br} \to f^2_1$					$N^2_{Br} \to A^2$
1975	N									
1976	N									
1977	N			N^1	N^1	N^1				N^1
1978										
1979	N^2		N^2_{e2}	N^1_{e1}	N^2_{e2}		$N^2_{e2} \to A^2$			N^1_{e2}
1980	$N \to A^2$	$N \to A^2$	$f^2_2 \to f^2_0$	$f^2_2 \to f^2_0$	$f^2_2 \to f^2_0$		f^2_2		$A^2 + A^1$	f^2_1
1981	A^2		A^2	← A^2	→					
1982				$N + A^2$	N^1_{Br}		$N + A^2$	N^2_{Br}		$N + A^2$
EE past 1970s										
present 1980s	5	4	3	2	2	2	3	3	3	4
future 1990s	5	5	5	4	4	4	3	3	3	5

small and nesting attempts apparently failed in both 1981 and 1982 (Momose, pers. comm.). In addition, the productivity of the population between 1977 and 1981 dropped to 11.6 percent compared to 13-14 percent before that (*Table 4*), although the total population increased by 28.8 percent in the same period (*Table 3*), again suggesting saturation of available habitat.

These data indicate that the cranes are becoming more tolerant of nesting in proximity to humans, but also that good habitat is limited and declining in eastern Hokkaido. Development projects are rapidly destroying crane breeding habitat.

THE PROBLEMS OF THE BREEDING HABITAT

Agriculture. Agricultural developments are the biggest threat to the marshes. *Fig. 9* shows the agricultural development areas in the Kushiro district. Kushiro Marsh, the biggest marsh in Japan, has eleven rivers running into it. Ten of them have nesting sites on their reaches and in addition the water levels of the rivers control the water levels of the marshes. The upper reaches of these rivers have been used for agricultural development. The rivers have been deepened and straightened. Ninishibetsu River (G6, *Fig. 8*), where a breeding pair has been observed every year since 1969, used to support 1568ha of marsh

Table 2. (continued)

	EZ1	F1	G1	G2	G3	G4	G5	G6	G7	G8
before 1966										
1966										
1967										
1968		N	N		N		N	A^2		
1969		N	N					N		
1970			N	N	N			N		
1971			N		N		N	N		
1972			N	N	N		N	N		
1973		N^2_{Br}		f^2_2	N^2_{Br}			f^2_2	f^2_1	A^2
1974		$N^2_{Br}+A^2$		$(f^2_1)\xleftarrow{1}$	N^2	N^2_{Br}	N^2_{Br}	N^2	f^2_1	N^2_{Br}
1975		N			N	N		N	N	N
1976										
1977	N	A^1		$\leftarrow N^2 \longrightarrow$				N^2	N^2	
1978		f^2_1		A^1			N		N^2	
1979		N^2_{e1}			N^2_{Br}	f^2_1	A^1	N^2_{Br}	$f^2_1+A^2$	N^2_{e1}
1980		f^2_1						N^2_{B-}		
1981	N?	f^2_1				N^1+A^1	N	N	A^2	
1982		A^1								A^2
EE past 1970s										
present 1980s	?	4	5	3	2	3	3	4	3	1
future 1990s	?	5	5	4	4	5	4	5	5	2

along its reaches. These have been destroyed by agricultural development since 1972, and in 1982, for the first time in many years, no nest was found. The four breeding sites G32, G33, G34, G35 (*Fig. 3*), on the upper reaches of two other rivers have been found in marsh alders (*Alnus japonica*), which grow in groups on drying marshes. Apparently no more reeds (*Phragmites communis*) remained in these marshes and yet cranes have made an effort to breed. Toberi Marsh in Tokachi (A1, *Fig. 2*) was also a traditional breeding site. A nest was observed almost every year between 1967 and 1980. The eggs were washed away in 1980 and no nest was found in 1981 or 1982. The marsh was completely destroyed for pasture except for the very center, where water remained but was too deep for the cranes to nest.

Straightening rivers causes not only the destruction of the marshes along the rivers themselves, but also the unstability of the water level on the connected marshes. Although there is an area approved as a Special Natural Monument in Kushiro Marsh (*Fig. 3*), it is only 17 percent of the whole marsh and it holds only six to seven pairs at the most. The monument area is located at the center of Kushiro Marsh where all the rivers converge. Recently, nesting sites have tended to move to the edge of the marsh, probably because of excessive water from the straightened rivers. Therefore, the Special Natural Monument is less important for the conservation of the Red-crowned Crane. Of the 119 nesting sites examined 53.8 percent have faced some kind of agricultural development.

Deforestation. Recently deforestation around marshes has been more of a threat. Spring runoff is accelerated when forests are removed, resulting in erosion of the hills, filling of the marsh with eroded soils, flooding of the marsh in spring, and drought in summer. Although reforestation is practiced, it takes many years before the young trees can benefit in the conservation of water and the prevention of erosion. In addition, many deforested

Table 2. (continued)

	G9	G10	G11	G12	G13	G14	G15	G16	G17	G18
before 1966										
1966										
1967										
1968				A^2			A^2			$\leftarrow A^2 -$
1969				N		N	N			$\leftarrow N -$
1970				N		N	A^2	N		$\leftarrow N -$
1971		A^2		N			A^2			$\leftarrow N -$
1972				N					N	$\leftarrow N -$
1973		A^2	f_2^2	N^2		N^2_{Br}			f_1^2	f_2^2
1974	A^1	N	$N^2 \rightarrow A^3$	f_1^2	A^2	f^2	f_1^2	SA^4	N^2_{Br}	f_1^2
1975	N	N		N				N	N	N
1976										
1977										
1978	f_2^2	A^2	A^2			f_1^2				
1979	f^2	f_1^2		f_2^2		N^2_{e1}	$N^2_{Br}+A^2$	N^2_{Br}	f_1^2	SA^2
1980	N^2_{Br}			N^2_{Br}				SA^4		A^2
1981		A^1		$f_1^2+A^2$	N	N^2	f_2^2	f_1^2		
1982		A^2		A^2	SA^6	$N^2_{Br}+A^2$	A^2			A^2
EE past 1970s										
present 1980s	3	1	1	2	2	1	3	2	2	2
future 1990s	4	2	2	3	3	2	3	4	2	2

	G19	G20	G21	G22	G23	G24	G25	G26	G27	G28
before 1966										
1966										
1967										
1968	$\longrightarrow$				A^2	A^2			$\leftarrow A^2 -$	$\longrightarrow$
1969	$\longrightarrow$				N					
1970	$\longrightarrow$	N			N					N
1971	$\longrightarrow$				N	N			$\leftarrow N -$	$\longrightarrow$
1972	N	N	N	N	N+N	N		N		
1973	N^2_{Br}	f_2^2	$N \rightarrow A^2$	N^2_{Br}	N^2_{Br}	$A^2 SA^2$	f^2		f_1^2	A^2
1974	N	N^2_{Br}	$N^2_{Br} \rightarrow A^2$	$N^2_{Br} \rightarrow A^2$	$N^2_{Br} \rightarrow A^2$	f^2	f^2		$N^2_{Br} \rightarrow A^2$	N^2_{Br}
1975	N	$\longleftarrow$	N	$\longrightarrow$	N	N	N	N		N
1976										
1977					A^2	N^1	N^1	A^2+Y^1	N^2	
1978		f^2	f_1^2	f^2	f_1^2			f_2^2		
1979	A^2	$\leftarrow N^2_{Br} -$	$- f_2^2 -$	$- f_1^2 \rightarrow$	N^2_{Br}	N^2_{Br}	f_2^2	N^2_{Br}	N^2_{Br}	f^2
1980					N^2		A^6		A^2	
1981					$f_1^2 \rightarrow A^2$					
1982					$N+A^1$		N^2_{Br}			
EE past 1970s										
present 1980s	2	2	2	2	1	1	1	2	3	3
future 1990s	3	3	3	3	2	2	4	4	4	4

Table 2. (continued)

	G29	G30	G31	G32	G33	G34	G35	G36	G37	GZ1
before 1966										
1966										
1967										
1968	A^2							← A^2	→	
1969	N			N						
1970	N			N	N		N	← N	A^2 →	
1971	N			N	N					
1972	N			N	N	N		N		
1973	f_1^2	N^2_{Br}		N^2_{Br}		N^2_{Br}				
1974	N^2_{Br}	N	f_1^2	A^2		A^2		f_1^2		
1975		N		N		N	N	N		
1976										
1977	A^1		N^1+A^1	N^1		A^2+Y^1		N^2		
1978										
1979		f_1^2	N^2_{Br}	N^2_{e2}	N^2	f_2^2	N^2_{Br}	N^2_{e2}	N^2_{e2}	
1980		$N \to A^2$		N^2_{Br}	A^2	A^2				
1981					A^2					
1982								A^1		
EE past 1970s										
present 1980s	2	2	3	2	3	2	3	2	3	
future 1990s	2	2	3	4	4	4	4	4	4	

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
before 1966										
1966										
1967										
1968										
1969					N					
1970					N					
1971					N					
1972	← N	N	N	→	N		N	N		N
1973	f_1^2	N	N^2_{Br}	N^2_{Br}	N^2_{Br}		N^2_{Br}	A^2	N^2_{Br}	N
1974	$N^2_{Br} \to A^2$	N^2_{Br}		N^2_{Br}	←	N →	f_1^2	A^2		N^2_{Br}
1975		N		N	N		N	N		N
1976										
1977	N^1	N^1	A^1				N^1			N^2
1978					A^2					f_1^2
1979	N^2_{Br}	f_1^2	f_2^2	f_2^2	$N \to A^2$		N^2_{Br}		N^2_{Br}	N^2_{e2}
1980		N_{Br}			f_0^2					
1981					f_1^2					
1982					f_1^2		$N+A^2$			
EE past 1970s										
present 1980s	1	2	2	2	4	2	1	2	1	1
future 1990s	1	2	3	3	5	3	1	3	1	1

Table 2. (continued)

	H11	H12	H13	H14	H15	H16	I1	I2	J1	K1
before 1966										
1966										
1967										
1968									A^2	←A^2–
1969										
1970										
1971									A^2	
1972				N	N				N	
1973				N^2_{Br}	N^2_{Br}				N^2_{Br}	A^1
1974	N^2_{Br}		f^2_2	f^2_1	N^2_{Br}		f^2_1	A^2	N^2_{Br}	
1975	N				N				N	←N–
1976										
1977	A^2	A^2	N^1+A^1				N^1		N^1	
1978	N^2		f^2_1	A^2					N^2	Y^1
1979	N^2_{Br}	A^2	N^2_{Br}	N^2_{Br}	N^2	N^2_{Br}	N^2		N^2_{Br}	N^2_{Br}
1980		←N^1_{Br}	⟶			A^1			f^2_1	
1981		N^2	$N^2 \to A^2$	A^2			N^2		$N^2 \to A^2$	N^2
1982			A^2	$N+A^2$	A^2				N	f^2_1
EE past 1970s										
present 1980s	1	1	1	2	2	2	1	1	2	1
future 1990s	1	1	1	3	3	3	1	1	4	1

	K2	K3	K4	L1	L2	L3	L4	L5	L6	M1
before 1966										
1966										
1967										
1968	⟶	⟶	⟶		A^2	A^2				
1969										
1970										
1971						A^2				A^2
1972		N			N			N	N	N
1973			f^2_2		N^2	f^2_2	f^2_1	$N \xrightarrow{2}$	(f^2_1)	f^2_1
1974	N^2			N^2_{Br}	A^2+A^3	A^1	f^2_1	f^2_1	f^2_2	N^2_{Br}
1975	⟶	⟶	⟶				N	N	N	N
1976										
1977	N^1		A^2	N^1	N^2		N^2		N^1	N^1+A^1
1978			N^2	f^2_1	A^2	N^2	A^2	SA^1	f^2_1	
1979		A^2	f^2_1	N^2_{Br}	N^2_{Br}	A^2	N^2_{Br}	N^2_{Br}	N^2_{Br}	N^2_{Br}
1980			A^2	$N+A^1$		$N^2_{Br}+A^1$		N^1_{Br}		$N \to A^2$
1981	N^2	N^2	N^2	$N^2 \to A^1$	N^2		N^2			f^2_1
1982				$N+A^1$	A^2+A^1		A^2	A^2		N^2_{Br}
EE past 1970s										
present 1980s	1	1	1	2	2	3	2	3	3	1
future 1990s	1	1	1	2	2	3	4	4	4	1

Table 2. (continued)

	N1	O1	OA1	P1	PA1	PZ1	Q1	R1	R2	R3
before 1966							N_{1964}			
1966							N		A^3	
1967							N	SA^1	N^2	
1968							N		A^2	
1969				N			t^2_1		$N+A^5$	
1970				SA^1			N			
1971				N		N	N	N		
1972		N^2		N		N^2	N	N	SA^3	SA^7
1973		t^2_1		A^1		t^2_1	t^2_1	t^2_1	t^2_1	SA^6
1974		$N \to A^2$		N^2_{Br}		N^2_{Br}	t^2_2	t^2_1		A^2
1975		N		A^2			N	N	A^4	
1976										
1977	N^1	N^1		N^2	A^1	N^2	N^1			N^1+A^1
1978							A^2	N^2		
1979	N^2_{Br}	A^2		N^2	A^2		N^2	A^2		
1980	t^2_1	A^2		$N \to t^2_0$			$N \to t^2_0$		A^2	
1981	t^2_2	$t^2_2 \to A^2$	N^2	N^2			A^2	$N \to t^2_0$		
1982	N^2	A^2		t^2_2			A^2	A^2		N^2_{Br}
EE past 1970s										
present 1980s	3	2	3	1	?	5	1	1	3?	1
future 1990s	4	2	4	1	?	5	1	1	3?	1

	S1	S2	T1	T2	T3	T4	T5	U1	U2	U3
before 1966										
1966	← N	t^2_1 →								
1967	← N	A^1 →								
1968	← N	→	N		N					
1969	← N	A^2SA^7 →	t^2_1							
1970	← N^1	→	N							
1971	← SA^1	→	N							
1972	← N	SA^4 →	N	t^2_1	N	N		N		
1973	← A^2A^2	SA^2 →	t^2_1	t^2_1	A^2	N^2_{Br}		t^2_1	t^2_1	t^2_1
1974	← N^2_{Br}	A^2SA^5 →	$N^2_{Br}+A^2$	N^2_{Br}	A^2	t^2_1		N^2_{Br}	t^2_2	$N^2 \to A^2$
1975	← A^5	SA^2 →	N	N	N	N		N	← A^6	SA^{15} →
1976										
1977	N^2AA	N^1+A^1		Y^1	N^1	N^1+A^1				N^1
1978										
1979	A^2SA^4	t^2_1	A^2	← A^2A^2	A^2 →	A^1Y^1	N^2_{e1}	A^1		N^1
1980	A^1	A^1		A^2+A^2	A^2			A^1		A^1
1981	$N^2 \to A^2$	$N^2 \to A^2$	A^1+A^1	$N^2 \to A^2$	t^2_1	$N^2 \to A^1$		N^2		N^2
1982	← A^{18}	→	N^2_{Br}	$N^2_{Br}+A^2$	N^2_{Br}	$N^2_{Br}+A^5$				A^1
EE past 1970s										
present 1980s	2	2	2	1	1	1	1	2	2	2
future 1990s	4	4	2	1	1	1	1	2	2	2

Table 2. (continued)

	U4	U5	U6	U7	U8	U9	V1	V2	V3	W1
before 1966										
1966			N							
1967	A^5SA^1		f^2_2							
1968			N							
1969	←	?	NNN*				N^2			
1970			N^1				N^1			
1971			NSA^5				N^2			
1972			N				N+N	A^2	N+N	N
1973	SA^{11}		f^2_1	A^2			N^2_{Br}		f^2_2	N^2_{Br}
1974	$N+SA^5$	$N^2_{Br}\to A^5$	N^2	A^1			$N+A^5$		$N^2\to A^2$	$N\to A^2$
1975		A^5	N				N		f^2_1	N
1976										
1977	A^2+Y^1	$\leftarrow N^1$	→				N^1+A^2		$N^2\to A^2$	N^1+A^1
1978										
1979	A^2			f^2_1	f^2_1	A^2	$\leftarrow A^1$	—	→	
1980			A^1	N^2_{Br}				A^2	A^2	A^2
1981	N^2						N^2	N^2	N^2	$N^2\to A^2$
1982			$N^1_{Br}+A^1$							
EE past 1970s										
present 1980s	1	1	1	3	3		2	2	2	2
future 1990s	1	1	1	4	4		3	3	3	2

	W2	W3	X1	X2	X3	X4	Y1	Y2	Y3	Y4
before 1966										
1966		N	N		← N	→				
1967	N	N	N		← N	→				
1968		N	N		← N	→				
1969		N^1	N		← N	→				
1970		N	N		$\leftarrow N^1$	→				
1971		N	N		← N	→				
1972	N	N	N		$\leftarrow f^2_2$	→				N
1973	f^2_2	f^2_1	$f^2_1+A^2$		$\leftarrow f^2_1$	$f^2_2\rightarrow$		A^1		
1974	$N\to A^2$	$N\to A^2$			$N^2\to A^2$	$N^2\to A^2$		N^2_{Br}		
1975	N	N			N	N				
1976										
1977	N^2	N^1			A^1		A^1	N^1+A^2		
1978								f^2_1		
1979		$f^2_2+A^2$		N^1_{Br}	N^1_{Br}	N^2_{e2}				A^2
1980		A^2				N^2_{Br}				
1981	f^2_1	N^2			$N^2\to A^2$	N^2	A^2	N^2	$N^2\to A^2$	A^2
1982	N^2_{Br}	$N^2_{Br}+A^1$	N^2_{Br}	A^2	$\leftarrow A^1$	N^1_{Br}	N^1_{Br}	N^1_{Br}		A^2
EE past 1970s										
present 1980s	2	2	2	4	2	1	1	1	2	2
future 1990s	2	2	3	5	2	1	1	1	2	2

Table 2. (continued)

	Y5	Z1	Z2	ZA1	ZB1	ZZ1				
before 1966										
1966										
1967		f_1^2	A^2							
1968										
1969										
1970						N				
1971		$N^{2?} \to$	A^2	A^2						
1972		N	N							
1973		N_{Br}^2	f_1^2							
1974		$N_{Br}^2 \to A^2$	f_1^2							
1975		f_1^2	f_1^2							
1976		$N \to A^2$	$N \to A^2$							
1977		$N^1 \to A^2$	$N^2 \to A^2$							
1978		N?	f_1^2							
1979		A^1	f_1^2							
1980										
1981	$N^1 \to A^1$		N^2							
1982	A^2	A^2	A^2	f_1^2	N					
E E past 1970s										
present 1980s	2	1	1	?	?	.4				
future 1990s	2	1	1	?	?	4				

areas are converted to farmland from which runoff and erosion go on unabated indefinitely. This is very serious around Kushiro Marsh. Kushiro is well known as a city of paper production and large areas of eastern Hokkaido have been deforested. The replacement of trees has not followed quickly enough to protect the marshes. One of the purposes of deforestation is agricultural development and in this case marshes are most affected. This has been an obvious problem in Furen Lake. The estuary of Furen River has been eroded by about 50m for the past six to seven years (Matsumura & Yamamoto 1980). This fact threatens the nesting sites U4, U5, U6 (*Fig. 6*). Shunkunitai (S1, S2, *Fig. 6*), has had the same erosion problem. Deforestation of the upper reaches of the rivers and agricultural development produce flooding and thus erosion of the river banks. *Fig. 10* shows the areas transformed into agricultural fields in the north region of Furen Lake between 1945 and 1975. The breeding habitats H1, H2, H3, H4, H7, H10 (*Fig. 4*), have mâintained their quality, but the hillsides around the marshes were all deforested (Koyanagi, pers. comm.).

Roads, Urbanization, and Other Development. Every kind of development involves the building of roads which brings disturbance for the cranes. A forest road was built behind the north end of Biwase Marsh (*Fig. 4*). Two nesting sites, L5, L6, visible from the road, have since been deserted, although pairs had bred in both sites before the construction of the road. In addition, this road will extend further west where L4 will soon be affected (Koyanagi 1980). A road will be constructed along Mochirippu Lake for a salmon hatchery. Nesting has been reported there (J1, *Fig. 4*) since 1972 (Nagatani, pers. comm.). The city of Nemuro has considered constructing a road between Nemuro and the town of Bekkai through five traditionally good breeding territories (S1, S2, W1, W3, *Fig. 6*) Cranes

Table 3. Rate of population growth of the Red-crowned Crane.

Period	Average increase	% of increase
1952-1956	52.8	
1957-1961	137.0	159.5
1962-1966	159.6	16.5
1967-1971	169.2	6.0
1972-1976	185.4	9.6
1977-1981	238.8	28.8

Table 4. Percentage of chicks in the Red-crowned Crane population from winter count.

Year	% of chicks in population	Average
1962	11.2	
1963	13.5	
1964	11.5	13.3
1965	14.5	
1966	15.8	
1967	17.4	
1968	13.0	
1969	10.5	14.3
1970	17.4	
1971	13.3	
1972	12.8	
1973	12.2	
1974	20.9	13.9
1975	6.8	
1976	18.4	
1977	9.4	
1978	9.4	
1979	13.7	11.6
1980	14.8	
1981	10.1	
1982	11.7	

are very sensitive to any kind of transformation of their environment and even a little-used forest road might easily cause cranes to abandon their nests. Part of Takkobu Lake (G12, *Fig. 3*), has been filled to straighten a road for a camping ground. This had been a traditional nesting site since 1969, but no nest was found in 1982.

Big cities with increasing populations are spreading rapidly. In Kushiro, the largest city in eastern Hokkaido, a nesting territory (G1, *Fig. 3*), was completely destroyed in 1972 to make a residential area for factory workers. In the southern part of Kushiro Marsh new houses and apartment buildings are lined up along the drainage ditches, facing the dried marsh. A sea port is being constructed at the end of Tonkeshi Marsh, (E1, *Fig. 2*). During construction, a pair bred on their original nesting territory, but after hatching their eggs, the pair moved to the upper reaches of the Otsu River to raise the chicks.

Predation is another hazard. A garbage dump has been located near the nesting spot at Tonkeshi. Crows are attracted by the garbage and have been identified as predators of cranes (Ehara, pers. comm.). The pair's desertion of their nesting site after egg hatching might be due to the threat from crows. In addition, the marsh has become dryer, and it is doubtful how much longer the pair can keep nesting there. Minks, which have escaped from captivity and become wild, can also be predators of cranes. They live in the

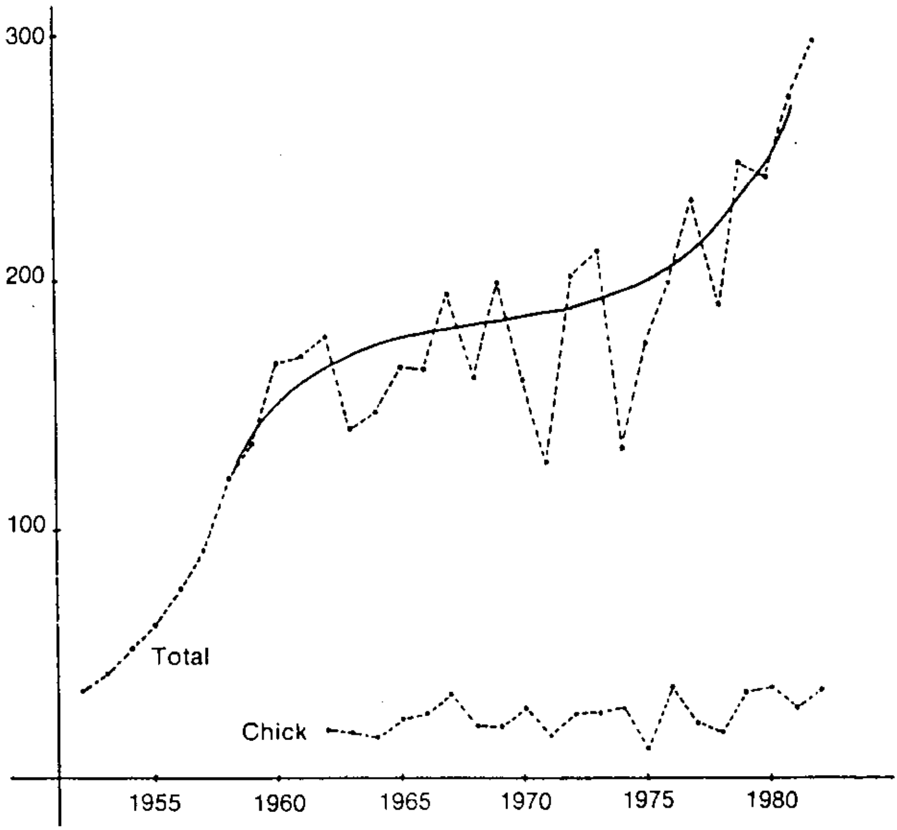


Fig. 1. Population of the red-crowned crane in the wild in Hokkaido, Japan.

marshlands, and thus pose a new problem, especially for the crane chicks. There are no predators for minks in Hokkaido and eventually they may become a serious problem (Miura 1974).

Gravel pits have threatened some nesting pairs. Breeding site F1 (*Fig. 3*), has faced a problem from gravel extraction on the north hillside. The marsh has been filled up and polluted with soil from this operation (Koyanagi 1980). G5 (*Fig. 3*) and N1 (*Fig. 4*) have faced the same problem. PZ1 (*Fig. 5*) was destroyed by the construction of a dam that dried up the marsh.

The roosting area in winter will not be discussed here in depth but it is also very important. Cranes need open water to stand in to sleep. The temperature in Kushiro often falls to -20°C in winter and all water freezes except the rivers. The upper part of Setsuri River and some other rivers in that vicinity have been used for roosting by cranes for many years. Many of these sites are threatened by canalization of the rivers, replacing the shallows with their tree lined banks by deep concrete canals.

ANALYSIS OF THE NESTING TERRITORIES

The results of the annual winter survey indicate that the number of Red-crowned Cranes in Hokkaido has been increasing (*Fig. 1*), which does not seem consistent with the development factors affecting the wetlands. In fact, in the early 1970s, it was said that the

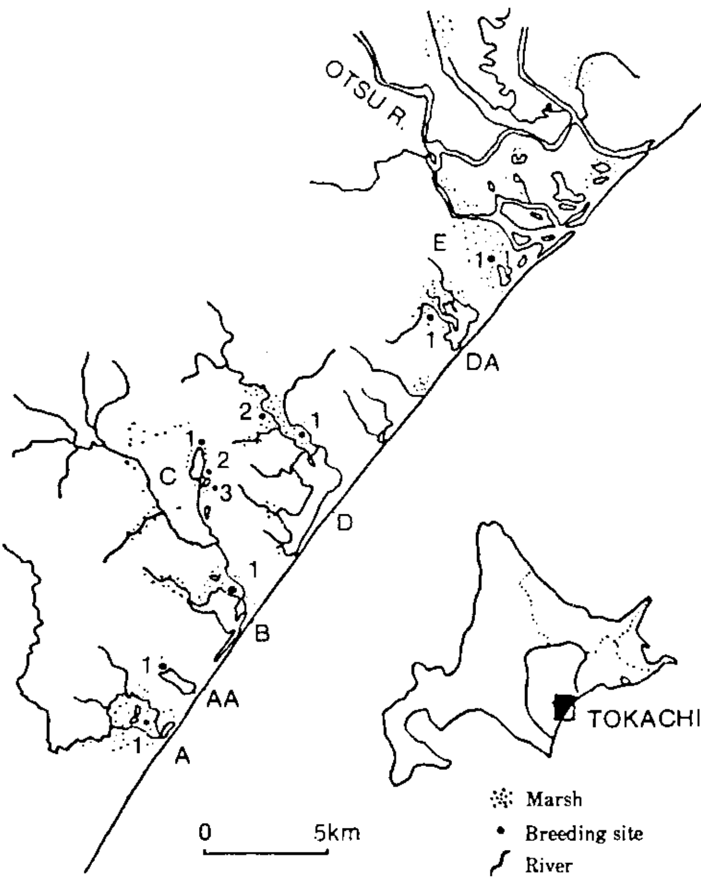


Fig. 2. Breeding territories from A to E in Tokachi.

Red-crowned Cranes would disappear from Japan in the near future. Contrary to that prediction, the population has been increasing. Was the prediction wrong?

My research indicates that the cranes will eventually disappear if the attrition of the marshland continues, although the cranes are slightly more adaptable to man than was thought possible, as shown by the recent nesting in smaller marshes near human disturbances.

In addition, cranes are long-lived, perhaps living for several decades, and rapid environmental changes may not cause an immediate drop in the population. As shown by the Tonkeshi (E1) pair, cranes sometimes have a strong tendency to stick to their traditional nesting sites despite development, and thus an immediate drop of the population is not evident. Perhaps many pairs are currently looking for new nesting sites, the scarcity of which induces young birds to breed on less than optional marshes.

What is the prediction for the next decade? This is projected by considering the nesting data and the development plan. Each nesting site is ranked from 1 to 5 to indicate decreasing habitat quality (*Table 2*). Data from the 1970s were not analyzed because of insufficient information on the individual nesting sites. A total of 119 nesting territories were analyzed (*Table 5*).

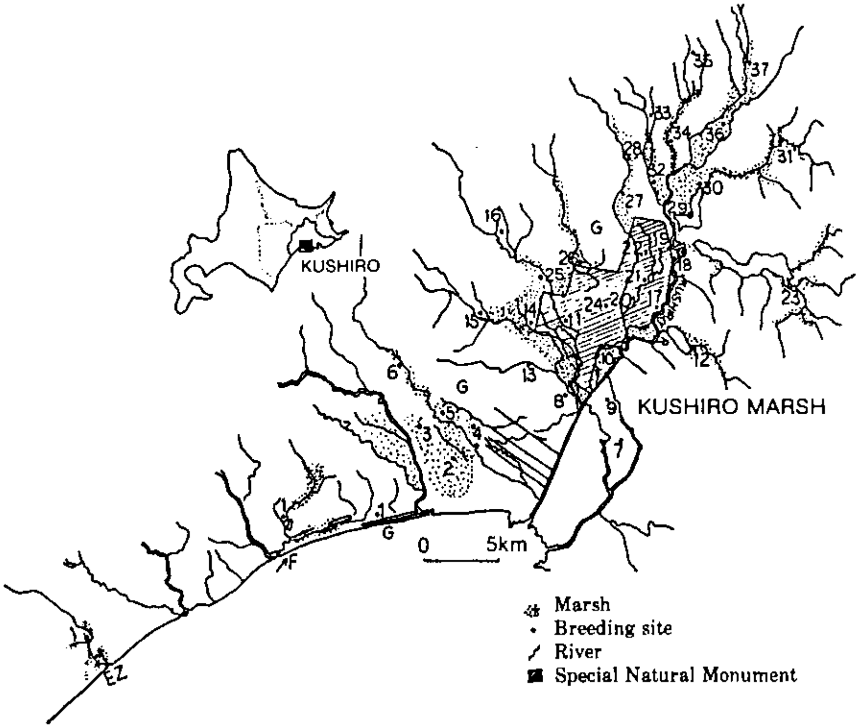


Fig. 3. Breeding territories from F to G in Kushiro.

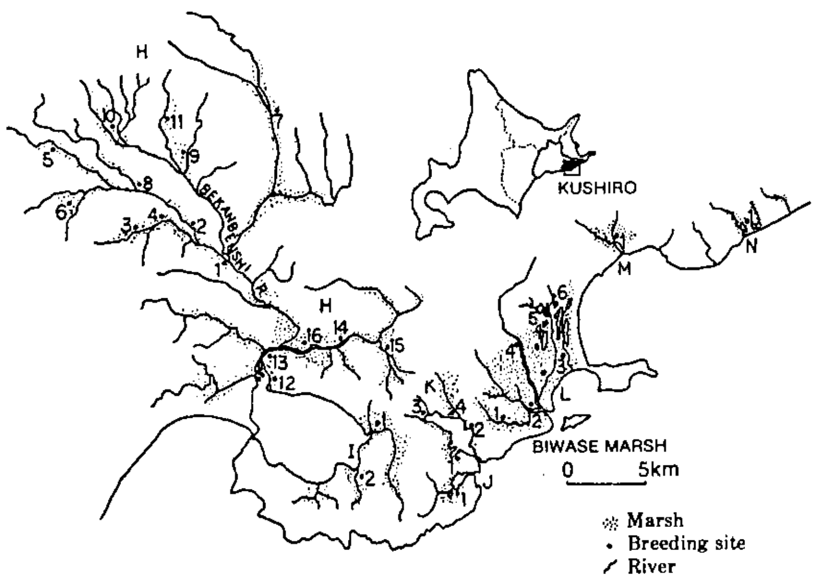


Fig. 4. Breeding territories from H to N in Kushiro.

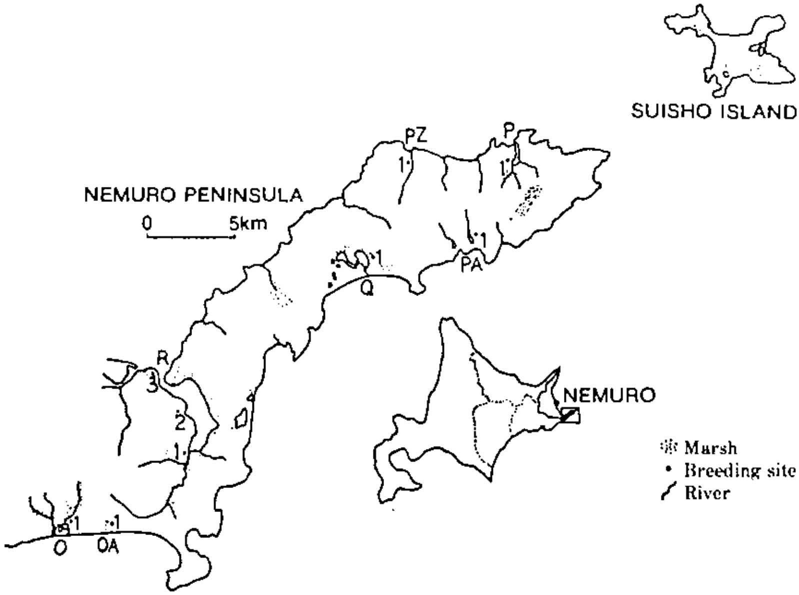


Fig. 5. Breeding territories from O to R in Nemuro.

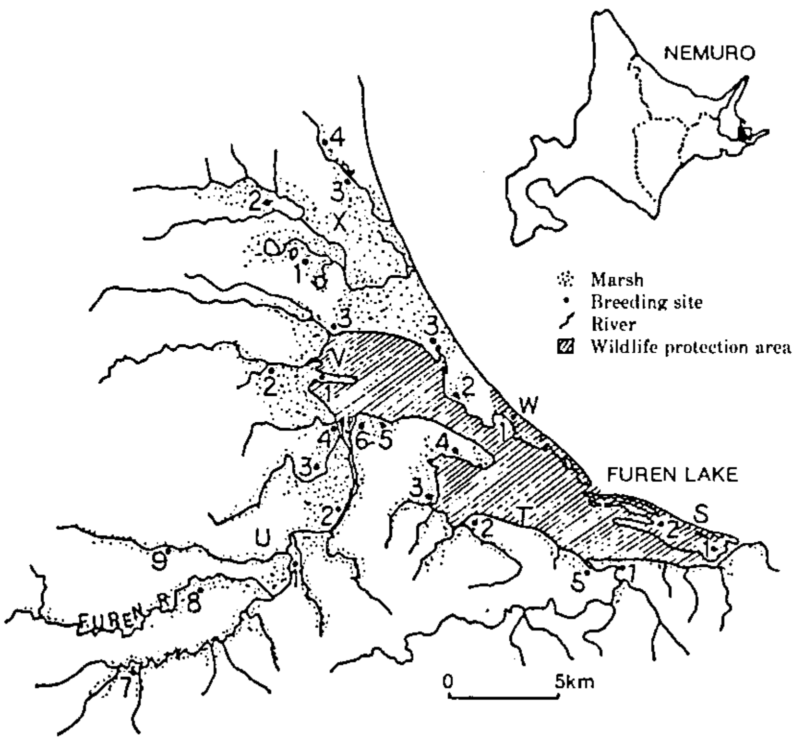


Fig. 6. Breeding territories from S to X in Nemuro.

Table 5. Percentage of the marshes in each category.

	1980s	— Percentages —	1990s
1 - pristine	35.3		25.2
2 - pristine but neighbouring problems	40.3		21.0
3 - on-site development	16.0		19.3
4 - almost completely destroyed	5.9		24.4
5 - habitat destroyed	2.5		10.1

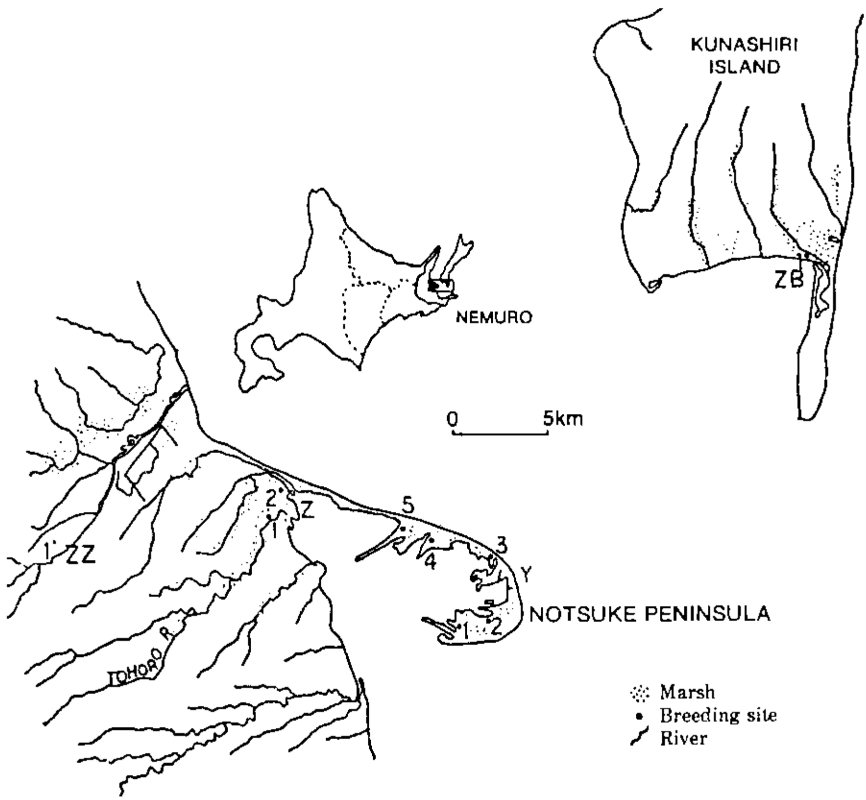


Fig. 7. Breeding territories from Y to ZZ in Nemuro.

Categories 4 and 5 include 8.4 percent of the crane breeding marshes in 1982 and are expected to increase to 34.5 percent by 1992. Some cranes are able to nest in category 4 areas (E1, F1, H5). Some are probably older pairs that tolerate a gradual deterioration of their habitat; others may be young pairs that moved into suboptimal habitat for lack of anything better. If the development plan is implemented as planned, it may very well accelerate beyond that rate.

Categories 1 and 2 are now 75.6%, but expected to be 46.2% in 1992. Each year a few new nesting areas are occupied, primarily through expansion of range, so there is a limited potential for expanding the number of the nesting sites. However, these new nesting sites

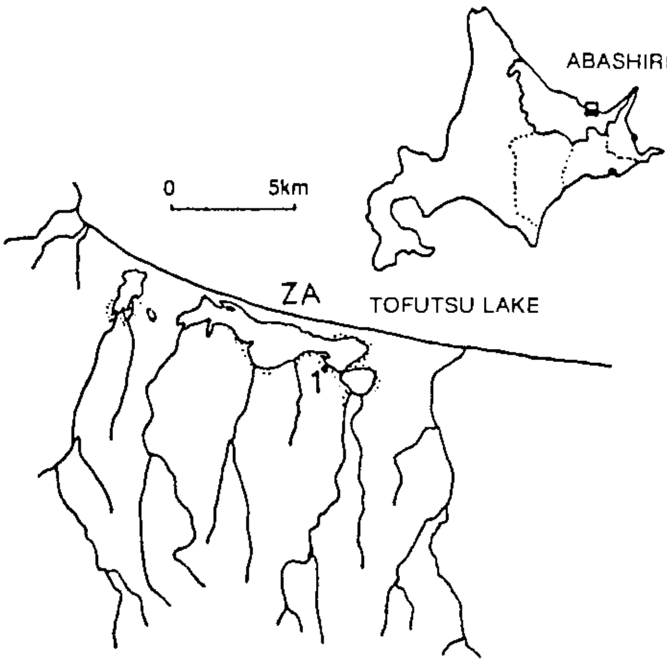


Fig. 8. Breeding territory ZA in Abashiri.

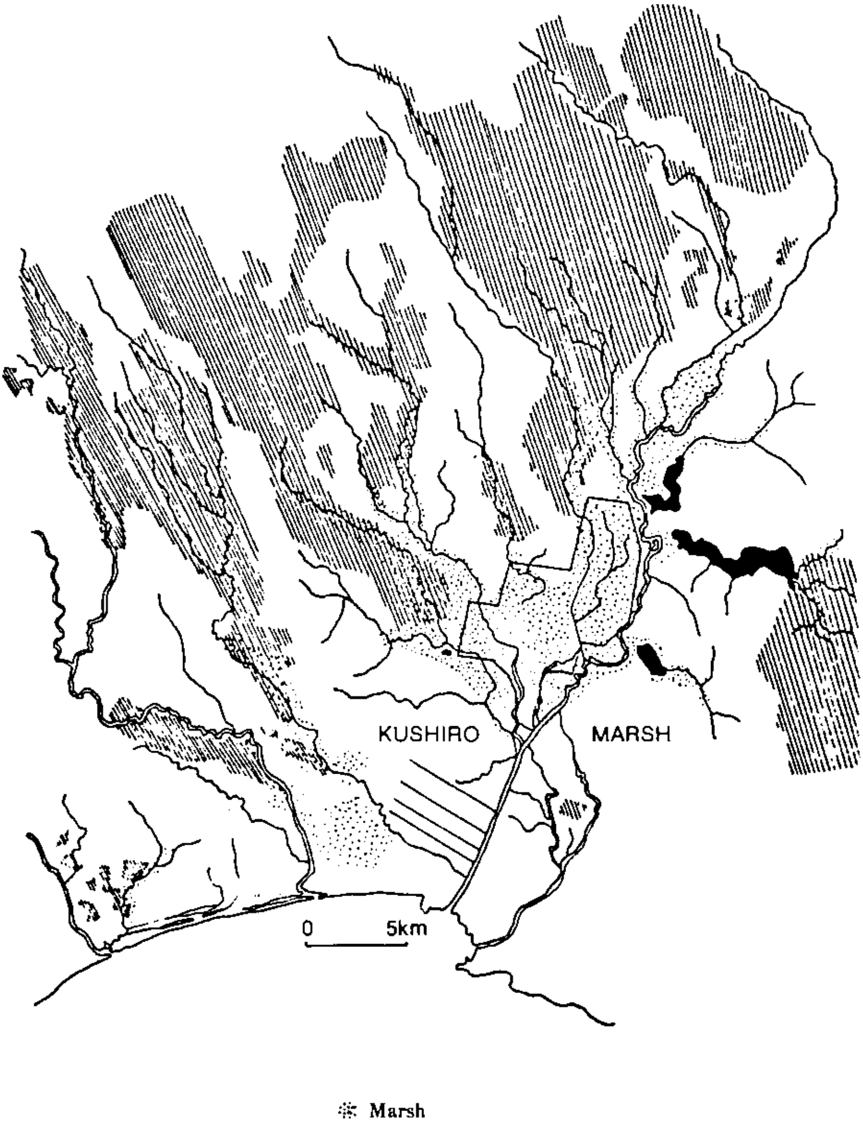
may not be adequate to support successful breeding, particularly on some of the as yet unoccupied marshes near Furen Lake.

Obviously, there are development limits beyond which the cranes cannot successfully breed, and a point may soon be reached when the productivity of the population will begin to decline on the limited and shrinking marshlands. Many mated pairs may live without breeding for several decades. It then becomes extremely important to monitor the productivity of the birds, as indicated by the percentage of immature birds in the winter flocks.

RECOMMENDATIONS

Each winter, an accurate count of the Red-crowned Cranes and their productivity is made by the Hokkaido Educational Committee. Air surveys of the breeding grounds providing data on the number and distribution of nests are carried out almost every year. Public education about crane conservation is often covered by the mass media. However, active programmes to protect the marshes are lacking. The seriousness of this problem is compounded by fact that the public has been assured that the population is increasing. Consequently, few realize the importance of protecting the marshes.

Several steps should be taken. First of all, the development around the 5012 hectare Special Natural Monument in Kushiro Marsh should be stopped or changed. Second, small marshes with one or two breeding pairs should be protected by local towns and cities. Third, the plan of road construction between Nemuro and Bekkai should be cancelled and Furen Lake, including the marshes along the lake, should be approved as a restricted area, its main purpose being the protection of wildlife. Fourth, a coordinated system of restricted areas, perhaps called "National Sanctuaries," should be considered for all of Japan.



Marsh
River
Lake
Special Natural Monument
Area of agricultural development

Fig. 9. Areas of agricultural development around Kushiro Marsh in 1980.

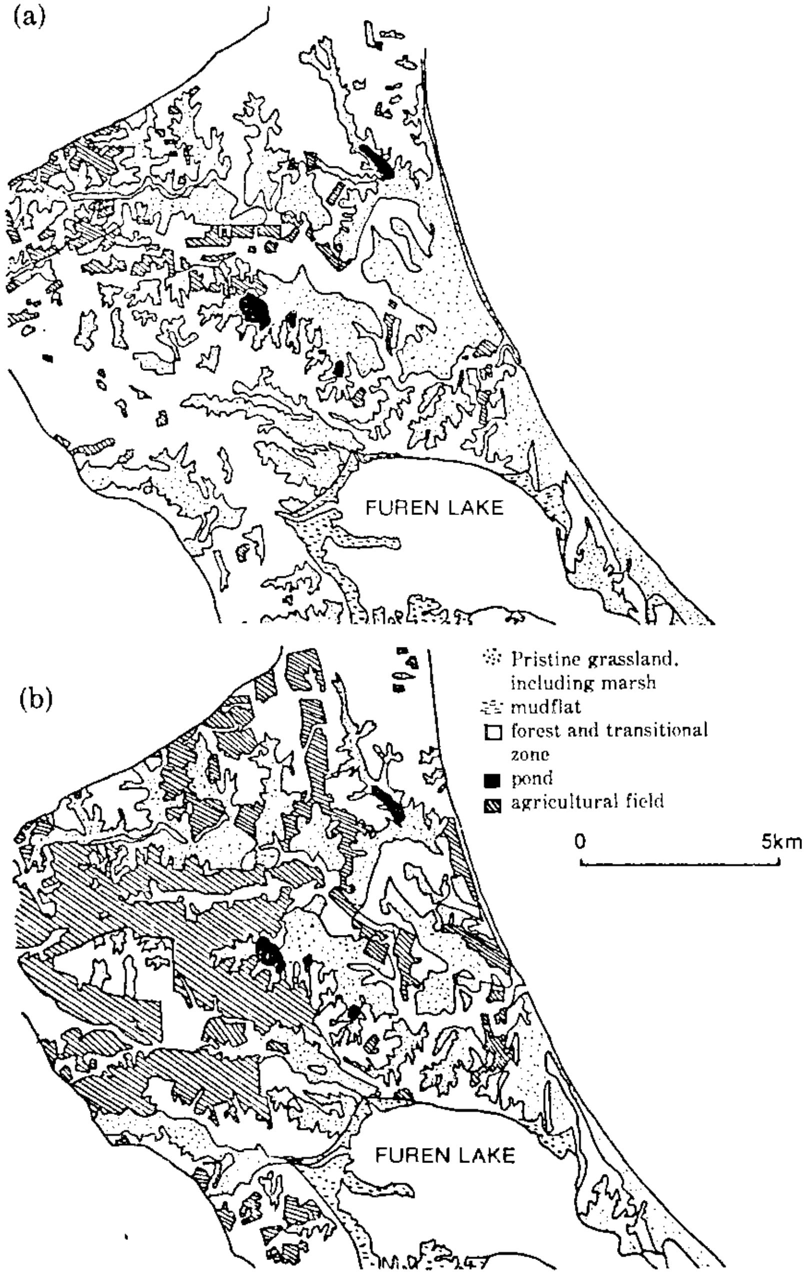


Fig. 10. Transformation of forests into agricultural fields around marshes in the north region of Furen Lake in 1945 (a) and 1975 (b) (Hokkaido Educational Committee).

Although cranes lay two eggs each year, most pairs usually rear only one chick. Researchers in Canada have found that collecting one Whooping Crane (*G. americana*) egg from each nest with two eggs augments the productivity of the wild cranes (Erickson 1976). In addition, the collected eggs establish a captive flock at the same time. Egg collecting could likewise be practiced in Hokkaido without detriment to the wild cranes. Many captive birds could then be established at both the Tancho Breeding Center and Kushiro Crane Park with resulting progeny distributed to marshlands in Northern Hokkaido that have yet to be colonized by cranes.

Crane research should be continued and expanded. Since 1977, all of the chicks of the Whooping Crane, which is much more endangered than the Red-crowned Crane, have been all colour marked, without harm to the population (Drewien & Kuyt 1979). Colour marking with plastic leg bands would significantly improve the quality of research for Red-crowned Cranes. Such study would provide insight into the longevity of cranes, the age of first breeding, the "loyalty" of breeding pairs to a particular nesting area, the extent of monogamy, and other important consideration that will help man develop a sound conservation programme for this species.

ACKNOWLEDGEMENTS

I thank the International Crane Foundation-Japan for supporting the air survey in 1981, Dr. Hiroyuki Masatomi for giving me his data and advice, Mr. Kunikazu Momose for spending many days collecting and analizing data, Dr. and Mrs. Shoichiro Satuski for providing their comfortable home during my research, and Dr. George Archibald for supporting this project in many ways. I also thank many others whom I am not able to list here.

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ON THE DISTRIBUTION OF THE RED-CROWNED CRANE IN THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

PAK U IL

Animal Conservation Society
DPRK Union of Nature Conservation
Pyongyang, Democratic People's Republic of Korea

The Government of DPRK emphasizes the necessity of worldwide protection of the Red-crowned Crane and the importance of international cooperation to help these treasured birds. It has therefore designated the birds and their living places as state natural monuments in April, 1946, and has established the state protection system for the conservation of cranes.

Every year toward the end of October, flocks of Red-crowned Cranes fly from the north into our country to winter. During their stay they live on scattered grain, grass seeds, grass roots, worms and field rats in the paddy and reed fields.

WEST COASTAL AREA

The main areas where Red-crowned Cranes winter in our country are the west coastal areas of South Hwanghae Province and Kaesong City (37°50′ - 38°40′N, 125°00′ - 126°30′E). These cranes cover the vast plains in Unryul, Changkjon, Ryongyon, Kangryong, Ongjin, Pyoksong, Taetan, Paechon, and Yonan counties, South Hwanghae Province and Panmun County, Kaesong City. As the cranes fly into this area, they settle first in the neighbourhood of Unryul County, South Hwanghae Province. When it gets colder they move south and winter in the above-mentioned counties.

The following numbers of Red-crowned Cranes have been observed in these areas in recent years:

229	November 1979 - February 1980
217	November 1980 - February 1981
224	November 1981 - March 1982

EAST COASTAL AREA

Red-crowned Cranes also winter in the east coastal area of our country. According to our investigations the main eastern wintering site is the neighbourhood of Kosong County, Kangwon Province (38°40′N, 128°10′ - 120°20′E) where 68 cranes were observed between December 1981 and January 1982.

The birds in the east also move south as it gets colder. Every autumn they first appear in Kumya county, South Hamgyong Province and later settle in the neighbourhood of Kosong County, Kanwon Province to winter.

Our observations indicate that birds that arrive in the west coast never fly to the east coast and vice versa. They all fly back north in flocks in March.

Every winter more than 290 Red-crowned Cranes winter in the southeastern and southwestern parts of our country. Taking into consideration that small flocks winter separately in different places, the number of Red-crowned Cranes is expected to be much greater.

EFFECTS OF ARTIFICIAL FEEDING ON CRANES WINTERING IN IZUMI AND AKUNE, KYUSHU, JAPAN

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ABSTRACT

Izumi and Akune districts in Kagoshima Prefecture, Kyushu, Japan, have long been known as wintering sites for Hooded Cranes (*Grus monacha*) and White-naped Cranes (*G. vipio*). Numbers had decreased during and after World War II. In 1962/3 artificial feeding was begun near the roosting site in Izumi, and around the same time the number of wintering cranes began to increase again. In 1981/2 about 5200 Hooded Cranes, 1100 White-naped Cranes, 3 Common Cranes (*G. grus*) and 1 Demoiselle Crane (*Anthropoides virgo*) were wintering in Izumi and Akune. Before 1962 the Izumi Cranes had left their roost at dawn and returned to it at dusk, but after artificial feeding started, most of the population began to stay at or near the roost even in the daytime.

INTRODUCTION

The crane populations wintering in Izumi and Akune districts on Kyushu had decreased during and after World War II. In 1962/3 artificial feeding was begun near the roosting site at Izumi, and around the same time the crane population began to increase again.

Both crane populations traditionally did not stay at the roosting site during the day. The Akune population still does not do so, but most of the Izumi cranes, which have been artificially fed near their roosting site, have started to congregate there even during the day.

There are few reports on the biology of cranes in Izumi and Akune (Archibald 1973, 1974; Nishida 1980; Yamashina 1978) and nothing is known of the effects of artificial feeding. The purpose of this report is to show the effects of artificial feeding on the population and the birds' tendency to concentrate at or near the roosting site in the daytime.

STUDY AREA AND METHODS

Izumi and Akune are in Kagoshima Prefecture in the west of Kyushu, southern Japan (*Fig. 1*). The Izumi plain is surrounded by hills on the south and faces the Shiranui Sea to the north. Akune is about 12km to the southeast of Izumi. The district consists of terraces and flatlands.

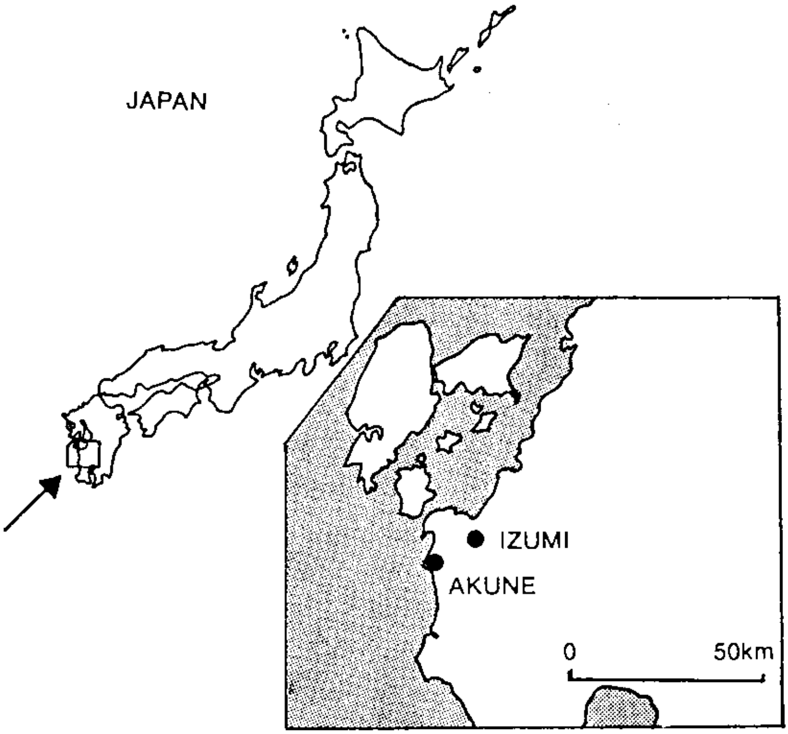

Fig. 1. Location of Izumi and Akune.

Distribution of cranes in the daytime and their roosting sites were mapped by means of direct observation and questionnaires from 28 February-5 March and 24 November-31 December 1980.

The censuses of wintering cranes in Izumi have been conducted by the Izumi Board of Education. Cranes disperse widely over the area in the daytime and fly back to the communal roost at dusk. The number of cranes flying out of their roost at dawn is counted by Mr. Sueharu Matano and pupils of Shou Junior High School. These counts are done some ten times each winter. The number of cranes leaving and returning was counted every 30 minutes at roost A in Izumi on 27 November 1980 and roost B in Akune on 24 December 1981.

Artificial feeding was initiated in 1962/3, supported by Izumi City and Takaono and Noda Towns. Data on the amount of food given to cranes have not been published. It was, therefore, estimated from financial budgets of food for cranes. Since the main food has always been wheat, food supply was obtained by dividing the financial budgets for food by the unit price of wheat.

To estimate daily food intake by a crane, the number of swallows was counted. It was difficult to follow a particular individual throughout the day at the feeding site because many cranes congregated there and the individual was hidden behind other cranes. So the number of swallows of one crane was counted for 30 minutes. These values were summed up. On the main feeding site, it was easy to count the number of swallows for a particular individual throughout the day. This was done for 10 adult Hooded Cranes (5 males and 5 females).

RESULTS

Two roosting sites were found, roost A in Izumi and roost B in Akune (*Fig. 2*). The former was used by all species of cranes and the latter only by Hooded Cranes. The farthest landing point of Hooded Cranes was about 10km from the roost. They spent the daytime in open places such as paddies, bean fields, and grasslands. White-naped Cranes did not disperse so widely. Their dispersal area was within about 5km of their roost (*Fig. 2*).

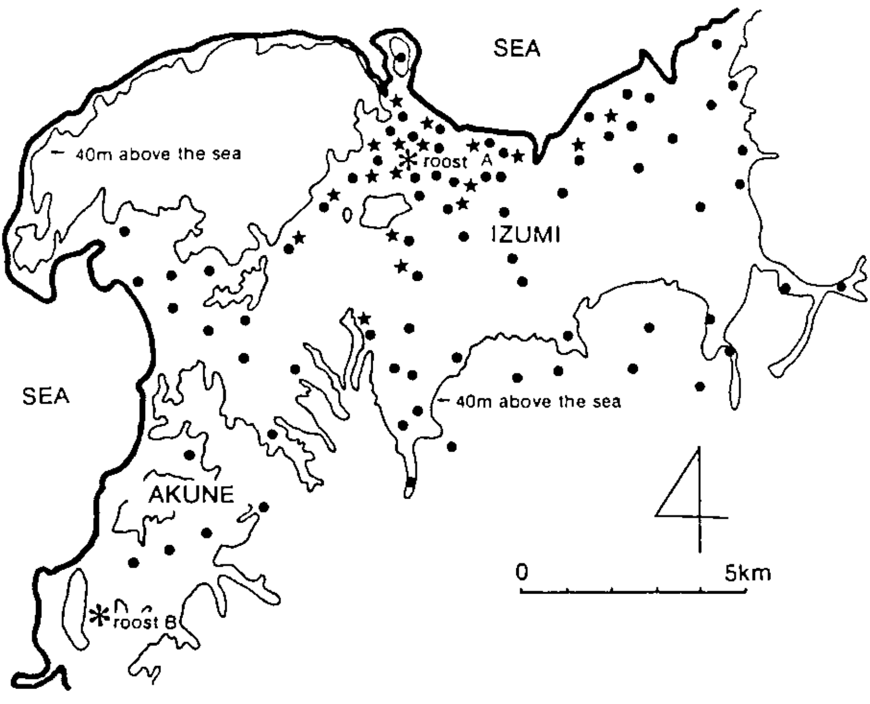

Fig. 2. Distribution of wintering cranes in Izumi and Akune districts, 1980.
•; Hooded crane, ★; White-naped crane,
*; roosting site.

The first flock arrives in Izumi around 20 October every year. The number of wintering cranes increases gradually from November and reaches a peak in late December. White-naped Cranes begin to return to their breeding ground in mid-February and Hooded Cranes do so in early March (*Fig. 3*).

In 1939/40 3435 Hooded Cranes and 467 White-naped Cranes were wintering in Izumi. Their numbers decreased rapidly during and after World War II: only 250 Hooded Cranes and 25 White-naped Cranes were recorded in 1947/8, and these numbers remained the same during the 1950s. In 1961/2 crane numbers began to increase again. The population of Hooded Cranes has increased rapidly and shows every sign of continuing to do so. In 1981/2 5127 Hooded Cranes were counted in Izumi, another 100 in Akune. White-naped Crane numbers have increased gradually and seem to have reached a plateau at about 1200 birds in recent years (*Fig. 4*). One Demoiselle Crane and 3 Common Cranes were also recorded in 1981/2.

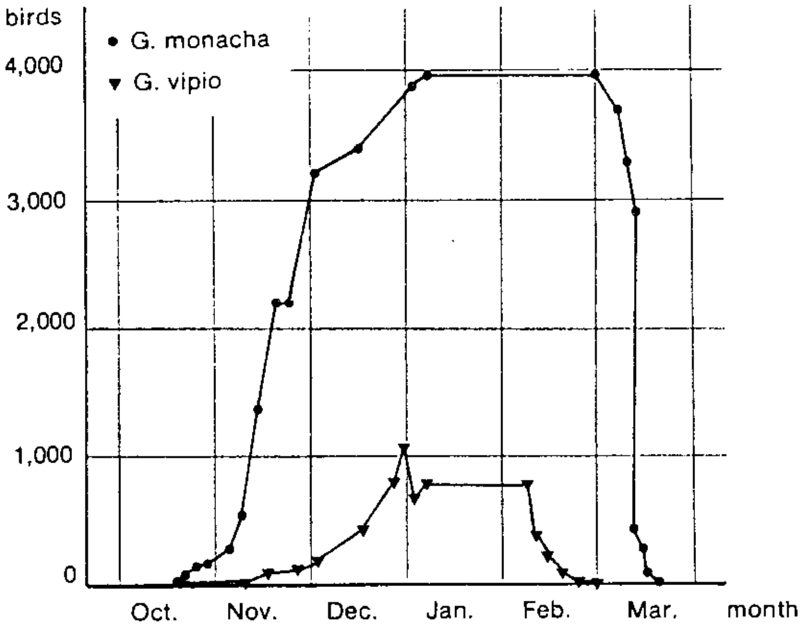

Fig. 3. Seasonal change in number of wintering cranes in Izumi, 1979-80.

Table 1. Frequency of swallows by a Hooded Crane per day.

Sex	Time of observation	Main food items	Frequency of swallows
	At feeding site		
	0805-1730	wheat	4965
	Out of feeding site		
	0730-1738	seeds of grass, rice	2869
	0715-1536	seeds of grass, rice	3291
♂	0712-1722	seeds of grass, rice	5173
	0705-1736	seeds of grass, rice	5259
	0710-1727	seeds of grass, rice	5260
	0720-1747	sweet potatoes, snails	1137
	0715-1749	seeds of grass, rice	1704
♀	0744-1736	seeds, blades of grass	2863
	0715-1738	seeds, blades of grass	4277
	0710-1740	seeds of grass, rice	4516
		Average	3635

* estimated value

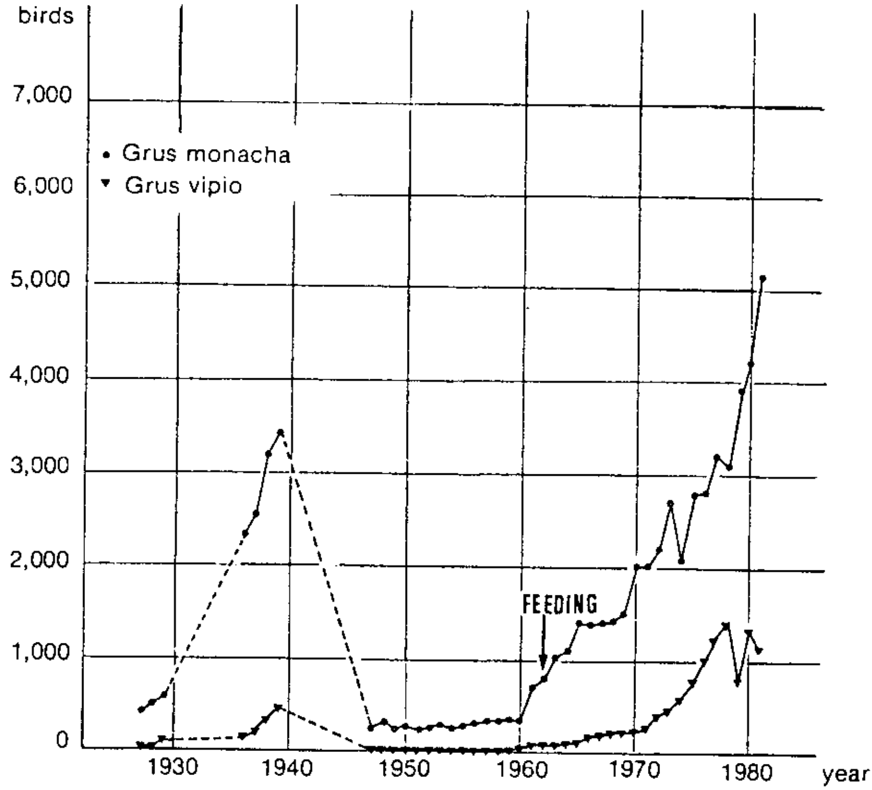

Fig. 4. Annual change in number of wintering cranes in Izumi.

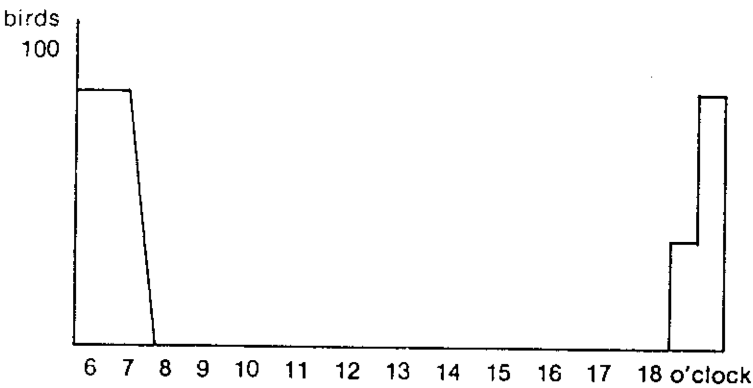

Fig. 5. Daily change in number of cranes at roost B, Akune, 24 Dec. 1981.

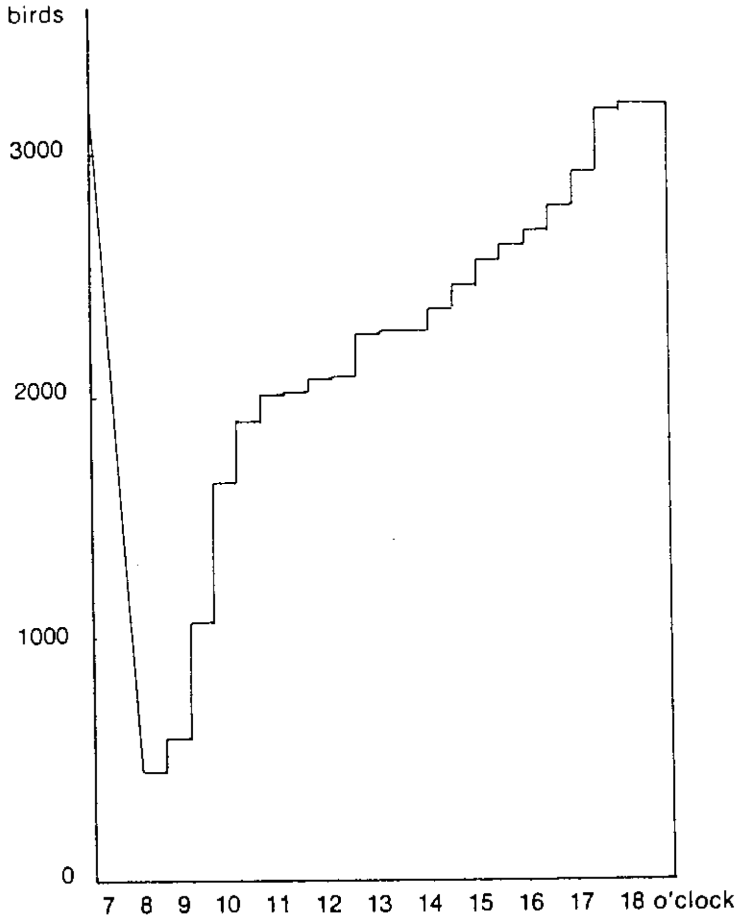

Fig. 6. Daily change in number of cranes staying at roost A, Izumi, 27 Nov. 1980.

Some people had given food to cranes before 1961, but artificial feeding on a large scale was initiated in 1962/3, when 13,410kg of wheat was set out. The amount of food given hardly changed from 1962 to 1967 and increased year by year from 1968 on; in 1981/2 the total amount of food was 57,860kg of wheat (*Table 2*). About 500kg of wheat is given daily.

Feeding behaviour of cranes was observed. Cranes dug the ground and pecked food items and usually swallowed one item at a time. At the feeding site they sometimes swallowed several grains of wheat at once. The number of swallows of a Hooded Crane per day was 4965 in the feeding site where wheat was set out. In a natural feeding site, where food items consisted of seeds, blades of grass, rice, etc., an average of 3637 swallows per day were recorded, ranging from 1137 to 5260 (*Table 1*).

Hooded Cranes begin to fly out of roost B at 0715 hrs and the last flock flies away by 0730. None remain at the roosting site in the daytime; they return at dusk (*Fig. 5*). At the roost cranes begin to leave at 0630 and most of them fly away by 0710 when a feeding car moves into the roosting site to scatter food. After that, most come back gradually to the roosting site and few cranes leave again in the daytime. All cranes return and roost together by 1800 hrs (*Fig. 6*).

DISCUSSION AND CONCLUSION

Increase in number of cranes

The number of wintering cranes has increased since 1961/2, coinciding with the start of artificial feeding in 1962/3.

Availability of food, that is, the contribution of artificial feeding to the crane population, is calculated from the following formula:

$$\frac{A}{I \times N} \times 100\%$$

A = total amount of food given to cranes in each season, I = food intake of a crane per day, N = total number of bird-day unit in each season. Total amount of food given to cranes in each season has already been mentioned (*Table 2*). The feeding rate (number of swallows per day) was calculated for Hooded Cranes but not for other cranes. Most of the cranes wintering in Izumi were Hooded Cranes; the values for other cranes were assumed to be similar. The value was 4965 in the feeding site where cranes took mainly wheat. The mean weight of a wheat grain was 30.6mg. Assuming that a crane swallows one grain at a time, food intake of a crane per day was 152g as calculated from 30.6 x 4965. Nishida et al. (1975) estimated that one adult Hooded Crane took 9295 grains of wheat or 278.9g per day in Yashiro, Yamaguchi Prefecture. The feeding rate of cranes in Izumi is about half that of birds in Yashiro. This difference may be caused by food dispersion, depending on how widely the wheat was scattered.

The total number of bird-day units was 486, 275 in 1979/80 (*Fig. 3*), which was 101.84 times as many as the maximum number of wintering cranes in the season. So the number in each season was estimated by multiplying the maximum number of cranes by 101.84. Total amount of food needed (*Table 2*) was calculated from I x N, or 152 x the maximum number of wintering cranes in each season x 101.84kg.

Availability of food calculated in this way ranges from 55.8 percent in 1966/7 to 111.2 percent in 1974/5 (*Table 2*). These percentages are high, suggesting that cranes are mostly supported by artificial feeding.

The rate of increase in the number of cranes was obtained by dividing the number of wintering cranes by that from the previous year (*Table 2*). Availability of food in the previous year and rate of increase in number show a significant positive correlation ($r=0.736$, $p<0.05$) (*Fig. 7*). On the other hand there is hardly any correlation between availability of food in the next year and rate of increase ($r=0.008$) (*Fig. 8*). Artificial feeding induced the increase in number of cranes. The amount of food was not increased because more cranes had visited than in the previous year.

The following three facts are clear: the increase in crane numbers coincided with the start of artificial feeding; the majority of the cranes are supported by artificial feeding; and there is a positive correlation between availability of food and increasing numbers of cranes the following year. The increase in population is attributed to artificial feeding.

Concentration at the roosting site

Roost B was in a paddy field with shallow water, which contained many small frogs, snails, etc. The Akune population, however, did not stay or forage there in the daytime. Similarly, the Yashiro population in Yamaguchi Preficture does not remain at its roosting site in the daytime (Kawarmura 1975). Therefore, it seems to be the natural habit for cranes to leave their roosts in the daytime. On the other hand, the Izumi population that has been fed near the roosting site since 1962/3, flew away in the early morning when alarmed by a car, but came back soon. Moreover, the population had not stayed near the roost before 1962 (Mr. Matano, pers. comm.). The change is thought to be caused by artificial feeding.

Artificial feeding seems therefore to have increased the crane population and made most of it remain at the roosting site even in the daytime.

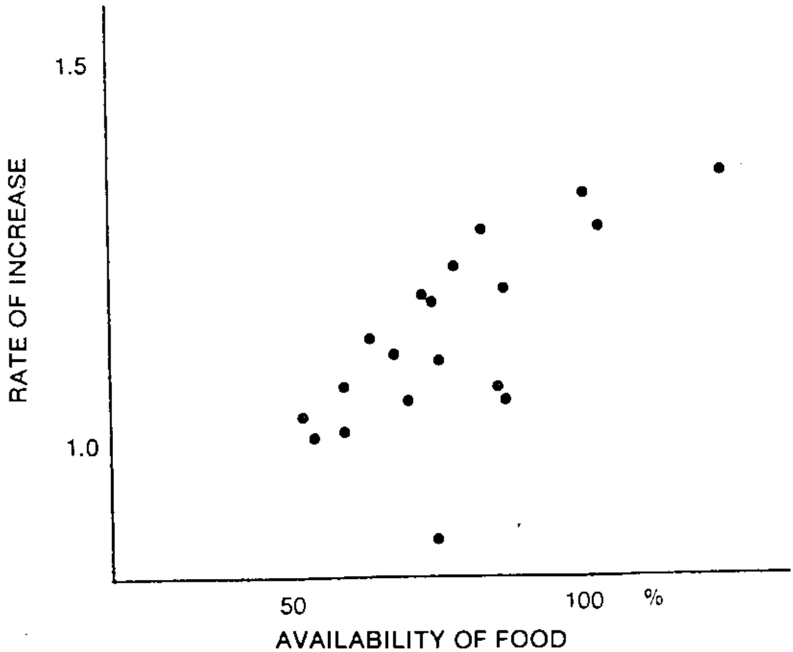

Fig. 7. Relation between rate of increase in the number of cranes and availability of food in the previous year.

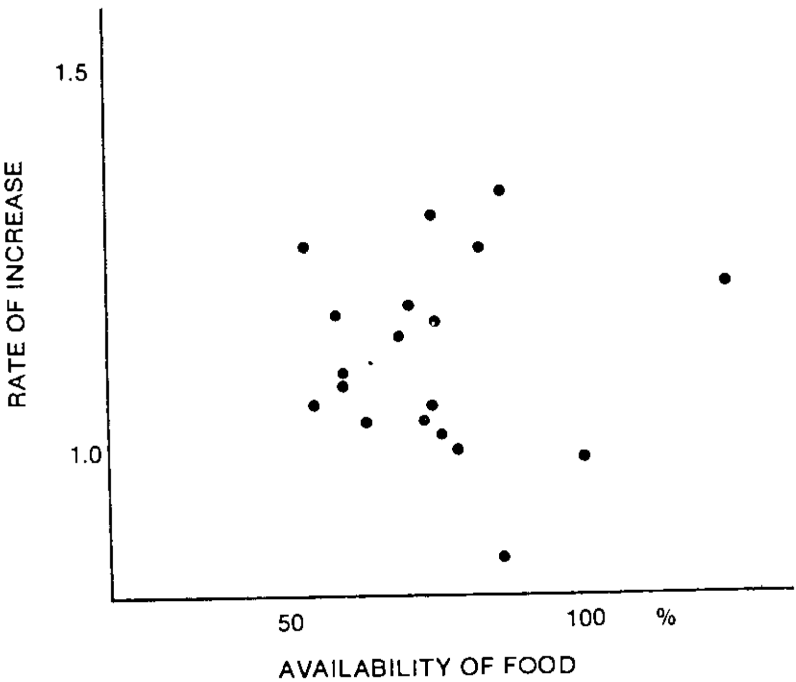

Fig. 8. Relation between rate of increase in the number of cranes and availability of food in the next year.

Table 2. Number of wintering cranes, rate of increase in number of cranes, total amount of food needed, total amount of food given to cranes and availability of food.

Season	Number of wintering cranes	Rate of increase in number	Total amount of food needed kg wheat	Total amount of food to cranes kg wheat	Availabiltiy of food %
1962/3	909	1.14	14,072	13,410	95.3
1963/4	1149	1.26	17,787	12,090	68.0
1964/5	1251	1.09	19,366	15,420	79.6
1965/6	1573	1.26	24,351	14,850	61.0
1966/7	1654	1.05	25,605	14,280	55.8
1967/8	1677	1.01	25,961	14,820	57.1
1968/9	1660	0.98	25,698	19,020	74.0
1969/70	1798	1.08	27,834	25,950	93.2
1970/1	2336	1.30	36,163	22,170	61.3
1971/2	2313	0.99	35,807	26,130	73.0
1972/3	2689	1.16	41,628	31,590	75.9
1973/4	3245	1.21	50,235	36,960	73.6
1974/5	2745	0.85	42,495	47,550	111.9
1975/6	3649	1.33	56,489	46,290	81.9
1976/7	3836	1.05	59,384	49,050	82.6
1977/8	4518	1.18	69,942	50,700	72.5
1978/9	4631	1.03	71,691	50,100	69.9
1979/80	4775	1.03	73,920	53,140	71.9
1980/1	5602	1.17	86,723	55,760	64.3
1981/2	6246	1.11	96,692	57,860	59.8

$$\text{Availability of food} = \frac{\text{Total amount of food to cranes}}{\text{Total amount of food needed}} \times 100\%$$

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TERRITORIAL AND FLOCKING BEHAVIOUR OF THE HOODED CRANE AT YASHIRO, YAMAGUCHI PREFECTURE, JAPAN

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ABSTRACT

In the first part of winter Hooded Crane (*Grus monacha*) families that arrive early maintain territories, which they defend against conspecific intruders. Later arrivals are less likely to find a site on which to establish a territory. All the cranes roost communally. In the middle of winter, diminishing food resources make it harder for families to defend their territories.

STUDY AREA AND METHODS

The study area is located in the Yashiro Basin, Yamaguchi Prefecture, Honshu Island, Japan. It consists mainly of terraced rice paddy fields crisscrossed by streams and footpaths. Observations have been conducted annually since 1960. Diurnal activities of the cranes were studied twice during the winter season, and their overall dispersion once every two weeks.

SEX AND AGE DETERMINATION IN THE FIELD

The sexes can be distinguished by their behaviour. Hooded Crane family units (a mated pair and their accompanying offspring) often establish exclusive territories on the wintering grounds which they defend vigorously against other conspecifics. When another crane approaches, the resident male stretches his bill upright, expands the bare red skin on the top of his head, and turning toward the intruder, gives a deep loud long call *kuurr* with the bill wide open. Just before he finishes calling the female adds her call, *kwat kwat* in high short tones but her bill is not stretched as high as the male's, and the red area on the back of her head is less obvious. This display is known as the unison call or synchronized duet of the mated pair. The sexual differences in calling behaviour was noted by several residents of Yashiro before my observations began and is confirmed by studies of the vocalizations of captive birds.

Juveniles are slightly smaller than adults, and their neck plumage is yellow rather than white. Their body plumage is more brownish and less grey and their calls are a soft *pit-pit-pit*. Juveniles can often be distinguished from one another by minor individual variations in the colour of their neck plumage.

TERRITORY

In the study area, family territories are located mainly toward the center of the Yashiro Basin. Territories are 1-10ha and their boundaries follow brooks, footpaths, and other natural or manmade borders. Territories are established in the same general area each year, but it is not known for certain whether they are occupied by the same pair in successive years. However, in one case a crane that was slightly lame occupied the same territory in three consecutive years.

The earliest arrivals on the wintering grounds establish their family territories, whereas other cranes (presumably later arrivals) do not form their own exclusive territories but mingle in flocks. However, some 'flock' cranes may establish their own territories if suitable unoccupied areas are available.

In the evening, territorial cranes join the flocks for communal overnight roosting and return to their territories early the following morning.

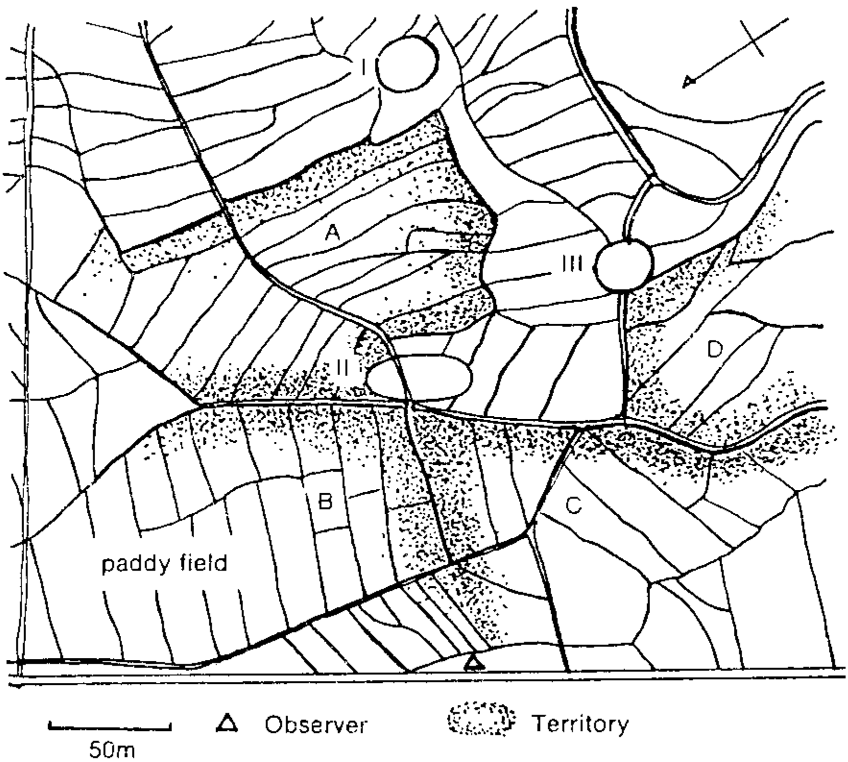


Fig. 1. Distribution of crane territories at Yashiro in 1977 I, II, III are feeding stations. A,B,C,D, are territorial families.

Defense of Territory

Conflicts between crane families occupying adjacent territories and between territorial cranes and flock cranes are common. The male is more active in the defense of the territory than his mate, and he is always on the alert for intruders. When other cranes invade or approach too closely, the male stands in front of the family and with his bill pointed toward the intruders,emits a shrill, single call. If the intruders persist the male may eventually

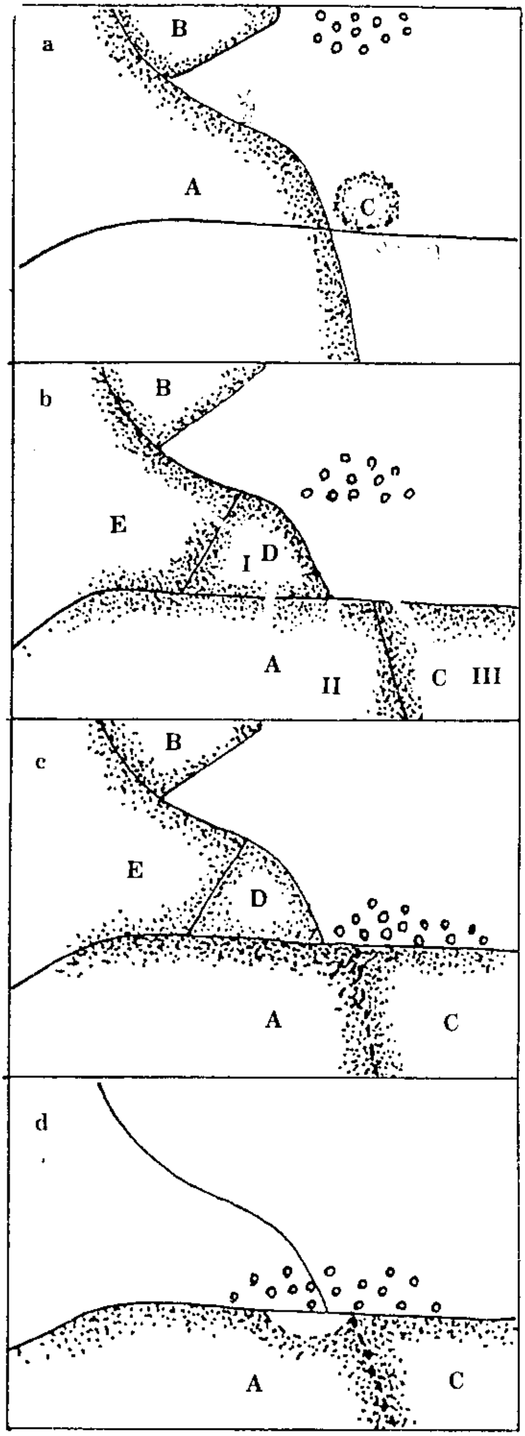


Fig. 2. Changes in territories among Hooded Cranes at Yashiro during the winter of 1977.

territory boundary

flock cranes

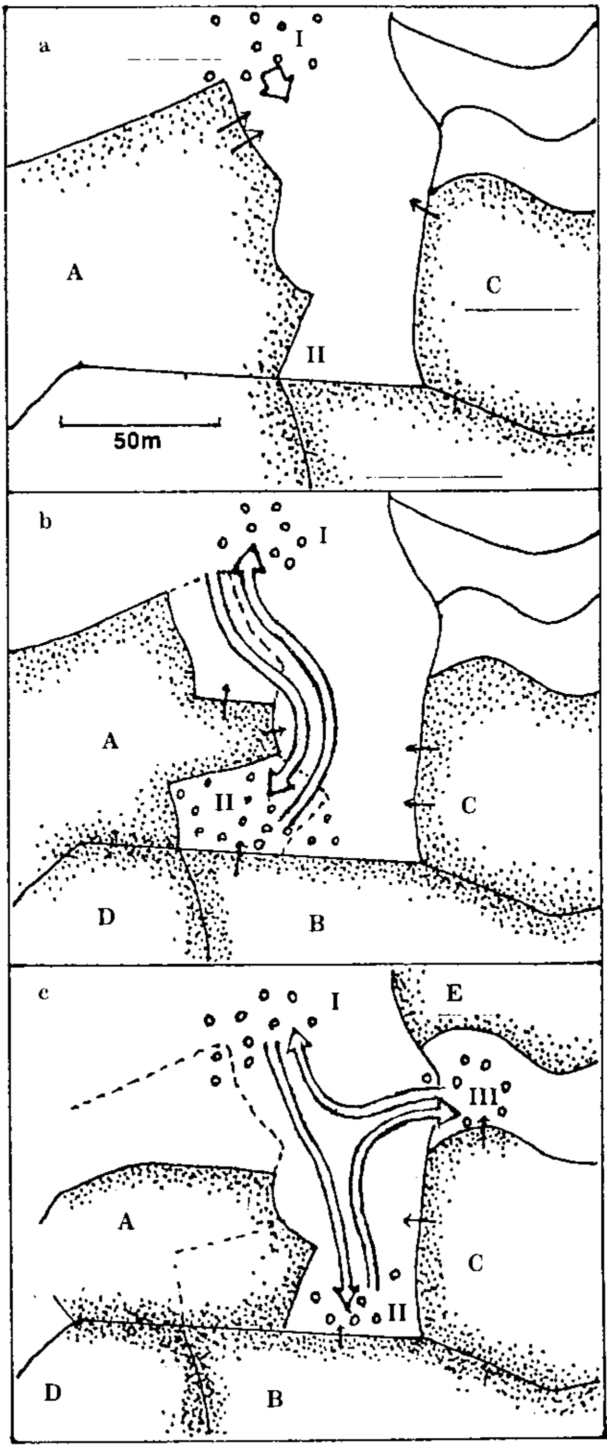
I, II, III: feeding stations
A, B, C, D, E: terrtitorial families

a. January 6, 1977

b. January 30, 1977

c. February 20, 1977

d. March 6, 1977



a. January 9, 1976

After the flock settled in the feeding place I, they tried to walk to feeding place II on a path between families A and C. Both A and C intervened.

b. February 10, 1976

The flock cranes land at Place I at dawn and over a 30 minute period they walk to Place II, all-the-while encountering opposition from Family A. At Place II they forage for about 2 hours, then walk back to Place I to rest. They repeat the movement to Place II in midafternoon.

c. February 25, 1976

The flock cranes kept away from Family A's territory and spread out more at Place I. Subsequently they used Place I as resting area, Place II as a feeding area, and Place III as a drinking area.

Key

I, II, III: feeding stations

A, B, C, D, E: territorial families

territory

flock cranes

movement of flock cranes

attacks by territorial cranes

Fig. 3. Movement of the Flock Cranes.

take flight and, followed by his mate and offspring, drive the intruders away from his territory by chasing them.

Very rarely is an active territory taken over by a new pair after such a confrontation, although adjustments in boundaries may occur, and territories may contract in size as a result of competition. In *Fig. 2* (a), Family A, which had arrived early in the season, dominated a broad territory which it defended against Family B and C, and non-territorial 'flock' cranes. By January 30th however, (*Fig. 2* (b)), as soon as Family C gained territory in Area III, Family A began to concentrate its defensive activities along the border between Area II and III. Meanwhile, families D and E slipped into a portion of Family A's territory, Area I, leaving Family A with a smaller territory. By February 20 (*Fig. 2* (c)), the same arrangement still existed, despite repeated efforts by Family A to regain Area I from Family D.

Advance of Flock Cranes on Territories

Early in winter, flock cranes usually land on Point I (*Fig. 1*) from which they scan the surrounding area. At this time, food is plentiful on the ground, mainly in the form of fallen rice kernels, and Point I is used as an important feeding area at this time of year. As winter progresses, food becomes less abundant in the area but the cranes still frequent the region around Point I as it is remote from roads and human disturbances. Flock cranes that land at Point I often try to advance to Point II, which abuts upon family territories (*Fig. 1*). At first, when flock cranes approach, the territorial cranes begin to call loudly and eventually chase them away (*Fig. 3*). In the middle of winter, however, as food supplies diminish, the territorial cranes encounter more difficulties in defending their territories against the advancing flock cranes, and they eventually admit the flock cranes into their territories, and may join them. For example, by early March 1977 (*Fig. 2* (d)), families B; D; and E had joined the flock, which now wandered freely over the three former territories, while Family A, though remaining separate, became less aggressive to the flock cranes, and even allowed them to feed in their territory.

STATUS AND ECOLOGY OF WINTERING HOODED CRANES IN THE LOWER REACHES OF THE YANGTZE (CHANGJIANG) RIVER OF CHINA

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ABSTRACT

Population, ecology and behaviour of Hooded Cranes wintering on the Yangtze (Changjiang) River are described. Protective measures are recommended.

INTRODUCTION

There are five species of cranes wintering in the lower reaches of the Yangtze River. They are *Grus japonensis*, *G. leucogeranus*, *G. grus*, *G. vipio*, and *G. monacha*. For many years, there had been no records of any Hooded Cranes (*G. monacha*) breeding and wintering in China because their populations had steadily declined. In the winters of 1980 and 1981, we found some flocks of Hooded Cranes wintering in Shengjin Lake in Anhui Province.

HABITAT

Shengjin Lake is on the southern side of the Yangtze River, located at 30°16′-26′N and 116°58′-117°11′E. The major part of the lake lies in Dongzhi County. The lake has an average area of 113.3km², a flat bottom 80 percent of which is silted, and its depth varies from 0.8m in winter to less than 3m in summer. At normal water level its waters flow through a sluice into the Yangtze River. There is a luxuriant growth of grass in the water with 55 kinds of aquatic and some hygrophylous vascular plants, and 61 species of fish live in it. As the water level drops in winter vast mud flats are exposed and since there is little human disturbance, large numbers of migrant waterfowl are attracted to the area to winter there.

POPULATION

We counted 99 Hooded Cranes in January and 124 in December 1981, but probably more than 200 cranes were wintering in the area each winter. The number of wintering cranes depends largely on rainfall in the previous summer. If there is heavy rain in summer, the water level in the lake will drop later than normal and the emerging grassy beaches will be too small to provide enough food and roosting sites for the cranes.

DURATION OF STAY, BEHAVIOUR AND DIET

Hooded Cranes arrive at Shengjin Lake in early November and leave in late March. The duration of their stay is about 145-150 days. In 1981, the first three cranes were seen on 22 October and by 20 March the majority of the population had left, the last cranes leaving by the end of March.

Hooded Cranes generally roost on the highest beaches as these are the first to emerge, have plenty of grass, and very little human disturbance. Large flocks of cranes fly to these roosts before nightfall (1730 hrs). When disturbed in one roost the cranes may change to another grassy beach around the lake, but they never stay in the water overnight.

In the morning they forage, most actively between 900 and 1100 hrs, and at noon they fly to some wet beaches to rest. While foraging they always maintain a strict vigilance and cannot be approached to within 200m before flying away. The staple food of the cranes is the rhizomes of *Vallisneria spiralis*, and they also eat rhizomes, tender shoots and fruits of *Carex unisexualis*, *Polygonum lapathifolium*, *Potamogeton malainus* and *Phalaris arundinacea*. Local people say that they also eat wheat shoots.

Although Hooded Cranes congregate in large flocks during the night, they break into small groups while foraging, mostly family units, but sometimes several families together. A survey of 42 crane families showed that 57.1 percent consist of two adult birds and one juvenile, 23.8 percent of two adults and two juveniles and 19.1 percent of two adults only. Occasionally a group of five birds (three adults and two juveniles) can be found. White-naped Cranes are also found in this area as well as large flocks of ducks, mainly Pintails (*Anas acuta*), and geese, and smaller numbers of Grey Heron, White Stork, Whooper Swan and, occasionally, Great Bustard. Hooded Cranes mix with none of these.

PROTECTIVE MEASURES

Many lakes on both sides of the Yangtze River have lost their capacity to retain water because of land reclamation, draining of marshes to exterminate a freshwater snail (*Oncomelania*, which is the intermediate host of blood fluke, the cause of schistosomiasis), and the building of sluice gates. Hooded Cranes wintering at Shengjin Lake are frequently disturbed by fishermen, herders, and hunters. It is therefore most urgent to protect the environment from further development and to ban hunting. The best method is to set up large nature reserves for the wintering migrants as soon as possible.

OBSERVING THE SARUS

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ABSTRACT

Nesting, social, and feeding behaviour of Sarus Cranes (*Grus antigone*) studied at Keoladeo Ghana Sanctuary, Bharatpur, India in September 1980 are described. Some 20 pairs breed at Keoladeo. The population also includes young and nonbreeding birds.

INTRODUCTION

Pairs of Sarus Cranes (*Grus antigone*) were observed for a fortnight in late September 1980 in the Keoladeo Ghana Sanctuary, Bharatpur. The object was to study breeding biology, feeding habits and territorial behaviour.

The total area of the Sanctuary can be conveniently divided into sectors by taking advantage of the tracks and bunds that crisscross the Sanctuary. The exact location of Sarus pairs found in these sectors can then easily be noted. Pairs were watched from 0630 to 1900 hrs or a little after nightfall with a break of three hours during midday. Observations were also recorded in moonlit nights. Activities near nests were recorded from a poorly concealed hide. Occasionally a flock that foraged outside Sanctuary limits was also observed.

POPULATION

Pairs. During the fortnight 20 Sarus pairs were seen within the Sanctuary, while existence of two more pairs was confirmed by foresters who saw them regularly at two grassy glades surrounded by deeper water and dense vegetation behind and in front of Shanti Kutir, the Forest Rest House. On any day 15 Sarus pairs could be easily sighted as these remained faithful to the same places day after day. The other five pairs were roving in the south and southeastern corners of the Sanctuary and presumably spent at least some time outside Sanctuary limits. The pairs are numbered from P1 to P20 in the order in which they were located (*Fig. 1*).

These 20 Sarus pairs displayed different stages in the life cycle of this bird. There were ten nonbreeding pairs, one pair was constructing a nest, six had nests, three had chicks and two had hatching eggs. Among nonbreeding pairs, courtship and an act of copulation was observed in two pairs (P4 and P19).

Identification of pairs. Sexes look alike in Sarus Cranes. But in a pair the female usually appears slightly shorter than the male. This may be due either to an actual difference in height or to the female's usually low posture. Females do not often appear to stretch to their

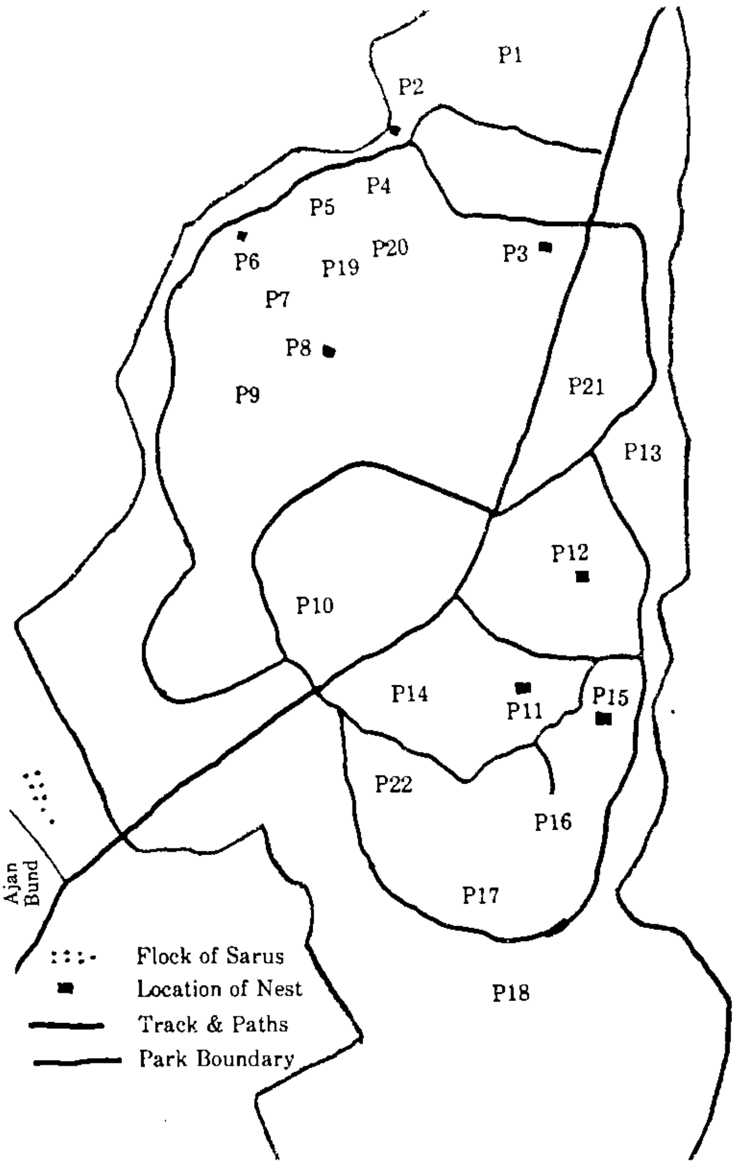

Fig. 1 Distribution of Sarus: Sept. 1980 Keoladeo Ghana National Park

full height. Identification becomes difficult when birds are some distance apart or if only one bird is present.

Another possibility to identify male and female Sarus may be the difference in the length of white on birds' necks. Low posture females generally had more white on their neck than the more erect males. This difference was noticeable in ten pairs, and to a lesser extent in four more.

The best means of identification of pairs appeared to be faithfulness to a particular place. Though one cannot be absolutely certain even about this, birds found at the same place day after day, may reasonably be assumed to be the same pair. P1, P2, P3, P5, P6, P7, P8, P9, P11, P12, P13, P14, P15, P19, and P20 are the pairs that were located at the same place or in the vicinity of the same place day by day.

A flock. Between Ajan Bund and the southwestern limit of the Sanctuary (see map) a flock of 18 Sarus Cranes was regularly seen foraging in fallow and partly flooded fields. The flock used this area and the surrounding cultivated fields for feeding, resting and roosting. At first the flock appeared to be more or less a cohesive unit, keeping to one field only where from time to time much gliding, dancing and bugling was in evidence. Some birds (probably males) would suddenly start pumping their necks up and down and would jump in the air. Such a performance might incite two or three other birds to repeat the act. This then stimulated some birds to give a call with parted wings and beak stretched skywards, the refrain being taken up by others. While feeding, a bird would suddenly part his wings and run smoothly as if on toes for a distance in one direction and back again to his original place. He would run so effortlessly that he appeared to glide or 'taxi on ice' (Lowther 1949). Other birds (possibly females) ran or glided in a rather low posture, parting their wings only slightly, keeping neck not straight but arched and beak held beyond the vertical. In such a posture they would dash up to a standing or feeding bird so close as to make the bird jump in the air.

As the days passed, the flock began to break up. A band of seven birds began to separate from the flock and to feed in a field nearer to the bund. Some birds apparently left the flock, as towards the end of the observation period only nine birds remained. Most of these appeared to have paired also as during the day four pairs were seen feeding in adjacent fields. Towards sunset, the nine birds gathered in a single field. But even then pairs kept to themselves and did not intermingle. Running, dancing, and calling were not in evidence.

Sarus are known to congregate in large flocks before pairing and this flock may have exhibited the typical pre-nesting behaviour of this crane.

Nonbreeding pairs. Ten pairs were not nesting. My observations relate mainly to P7, P10, P14, P19, and P20 (*Fig. 1*), pairs who remained faithful to a more or less defined area. The other pairs did not remain in one area but moved about, returning to their area during some time of the day.

The nonbreeding Sarus pairs spent their day preening, unison calling, and searching for food, the last activity consuming almost 80 percent of the day. In their search for food the birds walked about 75m, especially the males, looking up every two to three minutes, for about ten seconds before they resumed feeding.

BEHAVIOUR

Feeding. Paired birds were foraging close together. Sometimes, one bird walked some distance away, but came back to its mate after a short time. Pairs with chicks separated only when danger threatened but reunited quickly. In nesting pairs, the nonincubating bird normally foraged within their territory (P2, P6, P8, P11). Only in the case of two pairs, P3 and P12, were the birds seen to fly outside their territory for feeding.

Birds foraged on dry as well as on wet ground. Most of the time they were observed foraging on ground covered with water from a few centimeters to 35cm and with grass 20-100cm high. Occasionally a pair was observed on dry alluvial or ploughed ground, pecking at grains or small insects. Once a bird was seen investigating buffalo dung.

While searching for food in semiwet land covered with grass, the usual method was to probe vigorously near the roots or in the mud, occasionally pulling at the vegetation. Usually only the beak was immersed in water. But if the water was deep, Sarus were observed to immerse almost the whole of their long neck in it.

The Sarus is known to be an omnivorous species. My observations suggest that most of its food consists of small items only; feeding efficiency appeared to be low also. To satisfy their appetite, the cranes have to spend most of the day in search of food. They were observed foraging long after sunset and also on moonlit nights. No crane was seen to catch any larger animal, such as a fish, frog, or water snake, though I was told by foresters that they eat all these. Only twice I saw a crane swallow something big, the lump passing down its neck by peristalsis visible from some distance. One male Sarus was seen to evict an incubating Ring Dove (*Streptopelia decaocto*) from its nest, which was about 1.5m high in a bush, and to eat both of its eggs from the nest. The Sarus may also prey on floating nests or those on the ground or at low heights in bushes. Pheasant-tailed Jacanas (*Hydrophasianus chirurgus*) furiously attacking Sarus that strayed near their nests, were observed more than once.

Preening. Preening is the next important activity of the Sarus and occupies about 15-20 percent of its time. Some pairs interrupted their search for food from time to time throughout the day to preen. Others had long bouts of preening during midmorning, towards noon and in the late evening. A bird on the nest would often preen the feathers just below its neck and would stand on the nest from time to time to preen wing feathers and those on chest and abdomen. Before and after change-over birds were seen to spend a considerable time preening near the nest. They also preened while resting and standing on one leg.

Preening usually began with feathers below the neck and nape and those on the chest and continued with lesser, median, and greater wing coverts. Crown, nape, and cheeks were rubbed on the back and rump, probably to transfer oil from the uropygial gland to these parts. Claws were used to scratch under the chin and near eyes.

Sarus spend most of their time on the ground and were rarely seen flying. They may therefore need to spend less time preening than do actively flying birds.

Vocalizations. Sarus Cranes appear to have quite a varied repertoire of calls. Three variations of unison call were commonly noted. There was also a contact call of one single note uttered by one bird when the other was absent. The single note, high pitched, shrill alarm call was uttered by both birds. A long, deep, single-note call given by one pair continuously from midday to late evening was perhaps a distress call.

The first Sarus call was usually heard between 545 and 600 hrs. Pairs continued to unison call throughout the morning, the frequency decreasing after midmorning. Usually there were no unison-calls between 1200 and 1500 hrs. Some pairs called in the evenings; on moonlit nights calls were heard up to 2100 hrs.

According to Archibald (1976), usually the female Sarus initiates the unison call. In the field it was rather difficult to determine this with certainty. The call began with a short note, probably given by the female, and was followed by a longer note, probably given by the male. These notes then alternated from 8 to as many as 22 times. While calling, the female stretched her neck and pointed her beak skywards; the male also parted his wings.

The unison call appeared to have a variety of functions, e.g. threat, warning, and probably joy of being united after parting. One pair unison called when making the change over at their nest. Another called when a feeding pair ventured too close to their nest (P11), while a third pair called when the danger of buffalo trespassing into their territory receded. One pair unison called when another pair flew over their territory. A contact call was given when birds from a pair lost sight of each other. Thus, a bird from one pair gave a single note call continuously throughout one afternoon when its mate was nowhere in sight. They were seen together again the next morning. Once a flock of four Sarus Cranes flew over the sanctuary giving a single note call. This was answered by unison calls from pairs on the ground. P17 and P18 uttered a *croak, croak*, apparently expressing their surprise when I approached them unnoticed. Leading their chick away from danger Sarus were heard uttering a low, gutteral note, and a feeding Sarus was seen to scare away a buffalo that had come too near with a hissing sound.

Courtship. Courtship gestures were observed in pairs P2, P4, P15, and P19. Out of these, P2 was nesting and P15 nested during the period of observation. Courtship consisted of the male following the female, waving his neck up and down and jumping in the air. In one case he also ran in front of the female with partly spread wings. When the female of pair P2 was disturbed and left the nest, the male suddenly flew in and finding the female on dry ground, started pumping his neck and ran in circles; the whole act appeared to signify his joy at reunion.

An act of copulation was witnessed in pair P4. The pair was foraging on dry land surrounded by tall bushes one early morning (715 hrs). The male who was some distance away suddenly marched behind the female who crouched on bent legs, spreading her wings a little to steady herself. The male mounted on her back and with vigorous flapping of wings, completed the act. As he got down, the female remained in a crouching position for a second and then straightened. The male then did some more neck waving and jumping.

NEST AND YOUNG

Nest construction. According to Lowther (1949), the male Sarus provides nesting material by tearing up weeds from water and from land. The torn weeds are then taken by both birds to the nest site, where the female constructs the nest. I observed the construction of only one nest (P15). The pair approached the nest site with the female leading and the male following her, jumping and waving his neck up and down. The female began picking up aquatic vegetation from the edge of the water and throwing it over her shoulder to the nest site. It is possible that the male had put the material there, but he took no part in taking it to the nest site.

Nests. All the seven Sarus nests that I examined were surrounded by water on at least three sides. By late September the nest of pair P3 was on a mound on dry land; but when it was built in the middle of August, it too was in the water. Some Sarus pairs had used a natural rise in the ground for a nest (P2, P3 and P11), while others had made a platform for the eggs by heaping up vegetation (P6, P8, P12 and P15). The nests of pairs P2 and P3 had little or no lining of vegetation under the eggs, while in all other nests the eggs rested on a thick pad of vegetation.

The nests of pairs P6 and P12 contained only one egg, the other four nests had two creamy-white eggs heavily soiled by mud.

Incubation and hatching. In Sarus Cranes both sexes incubate the eggs, but their share is probably not equal. I have seen the change over taking place regularly every hour in one pair (P2), while in other pairs (P11 and P12) there was no change-over even after three to four hours. In pair P2 change-overs were frequent in the mornings, less so during mid-day, and very infrequent in the evenings. Probably the female does take the major share, as she was seen sitting on eggs in most cases (P2, P3, P11 and P12) during the evening.

The change-over was not accompanied by any ritual except in one case (P8) where the birds unison called at that time. The bird taking over normally approached the nest from a particular direction and first stood preening for some time a few meters away. As it came closer, the sitting bird got up and preened also. They then changed their positions, the bird taking over first preening, then rearranging eggs and vegetation, revolving itself over the nest and then sitting down. In most cases it stood up once or twice to rearrange and then finally sat with a little shuffle. In the evenings, when there normally was no change-over, the sitting bird got up every 20-25 minutes, preened or went away from the nest a little to drink or to feed. At midday the incubating crane often opened its beak for cooling. Sarus are not disturbed by roaming local shepherds and their cattle. But if a stranger appeared in the vicinity the incubating bird immediately left the nest. Smaller birds such as Egrets (*Egretta intermedia, Bubulcus ibis*), Red-wattled Lapwings (*Vanellus indicus*), Black-winged Stilts (*Himantopus himantopus*) and even House Crows (*Corvus splendens*) that were often seen in the vicinity of crane nests were ignored.

The exact incubation period of Sarus eggs does not seem to be accurately known. Estimates varied from 28 to 40 days. Eggs from two nests hatched during the present investigation. Eggs of P3 hatched on 23 and 25 September probably after an incubation of 34 days but the exact date of the completion of the clutch was not known. The actual hatching was watched from a hide by two experienced wildlife photographers. According to them the second egg hatched 36 hours after the first egg. The younger chick was rather weak, as it had to be helped out of the egg by its mother. It was so limp that a Jungle Crow (*Corvus macrorhynchos*) immediately tried to peck at it, when its mother came it its rescue. The family left the nesting area immediately thereafter, probably because the nest was quite close to the main road and on dry land where the birds were constantly disturbed by curious onlookers.

The single egg in the nest of pair P12 was hatched late in the evening of 27 September and the chick was seen early next morning when the brooding bird stood up to preen. Twelve hours after hatching, the chick was still not able to leave the nest. It was offered food by the parents but refused to take it that morning. Even after 48 hours, the family stayed near the nest while the chick was moving within only a two meter radius of the nest when the last observations were taken.

Pairs with chicks. Pairs P1, P5 and P12 each had only one chick, P13 had two. During the day, the adults were searching for food in their territories with the chick in tow. Chicks were offered food by both parents; the chick took it from the tip of the beak. In a continuous observation of one hour, the chick was offered food nine times. The parents systematically thrashed the grass in the water with their feet, probably to disturb insects. Most of the food offered was small animal matter, difficult to identify from a distance. It was also difficult to make long, continuous observations, as the families were constantly on the move and often hidden behind bushes and trees.

When I tried to get closer, one of the parents gave an injury-feigning display by lowering its neck, bending its legs and spreading its wings and tried to lead me away. The other parent either lead the chick away or the chick froze in the grass. In one instance, the parents gave sharp pitched, single note alarm calls as the chicks went into hiding and the parents went their separate ways. At one time a Pallas's Fishing Eagle (*Haliaeetus leucoryphus*) flew past P1, obviously trying to grab the chick. At this the male let out a sharp cry, opened his wings and the chick took cover between his legs. The female, who was foraging a few meters away, rushed to the chick immediately. Chicks, however, were more often seen with the females, the male often wandering away from the family.

At dusk these pairs generally roosted on a little rise in their own area, the female sitting down and the chicks struggling to get under her wings and the male feeding or preening close by.

Predation. The only predators that can possibly harm a Sarus family are fishing eagles and Black-necked Storks (*Xenorhynchus asiaticus*). In winter a number of migratory eagles arrive in the Sanctuary that may also pose a threat to young cranes. When eggs and chicks are unattended, often due to human interference, House and Jungle Crows and Marsh Harriers (*Circus aeruginosus*) may also try to prey on them. It is however, pertinent to note that family P13 roosted under a tree that was next to the nest-tree of a pair of Pallas's Fishing Eagles.

I was told by foresters that occasionally snakes, including pythons, and jungle cats take Sarus eggs and chicks.

Roosting. As already stated, pairs with chicks roosted at a convenient place in their territory. In the case of pairs with nests, the nonincubating birds were normally seen away from the nests, either foraging in one corner of their territory or they were not seen at all in their territory. While nonincubating birds from P6, P11 and P 12 were seen to be in their territory at the time of nightfall, those from P2, P3 and P15 were out of sight. The nonincubating bird from P8 displayed a peculiar behaviour. He used to come nearer other nonbreeding pairs such as P7 and P19 and they all stood together at nightfall. Is it possible that these birds belonged to the same flock before birds of P8 paired? The other non-nesting pairs such as P4, P10, P14, P20 roosted as pairs in their own territory. Usually after sunset the female would finish her feeding first and would sit down at a place while the male continued to feed. After 30 minutes or so, he would come nearer his mate when she would stand up. At the time of nightfall, birds were invariably observed in a standing position and preening themselves. They probably roosted in this position. Though the actual roosting spot may be dry, the area in general can only be described as wet.

TERRITORIAL BEHAVIOUR

Intraspecific Behaviour

A few instances of intraspecific behaviour were noticed. Pairs P8 and P9 had adjacent, almost overlapping territories and both regularly foraged in each other's territory. But when pair P9 came too close to the nest of pair P8, the latter unison called and pair P9 retreated. A Sarus pair was seen foraging near the southern most road of the Sanctuary in the territory of pair P18. Another pair (probably P18) flew in, landed close by and immediately gave a unison-call. The first pair then walked away and crossed the road, probably returning to their own territory (P17). One pair (P13) also unison called when another Sarus pair flew over their territory.

At dusk birds from pairs P7, P8, P19, and P9 came together to roost.

As will be seen from the map eight Sarus pairs are concentrated in an area of about 2 sq km. The approximate size of the territory for each pair comes to about 250 sq m. As is already noted, the territorial behaviour of these closely packed pairs varied. While pairs freely entered each other's territory for feeding and some of them came together for roosting, proximity near the nest was not tolerated.

Pairs with chicks were found to be quite mobile. P1 had a large area, about 1.5 sq km all to itself, where it moved freely; P5 and P13 not only moved within their area but often crossed the roads to enter other areas. Their presence was tolerated by adjacent pairs such as P6 and P12 (see map).

P10, P11, P12, P14 also commanded large territories of about 0.75 sq km each. Occasionally other Sarus were seen feeding in their territories. Their presence was seen to be tolerated. P17 and P18 had adjacent territories divided by a road. As already indicated P17 probably did not tolerate P18's presence in its territory. But in another instance when both the pairs were disturbed by a gang of shepherds, both resorted to the area normally covered by P18.

These preliminary observations suggest that the Sarus Crane is perhaps not very parochial in its adherance to a particular territory. Its behaviour appears to be quite flexible and tolerant towards its own kind.

Interspecific Behaviour

An incubating Sarus would take no notice of birds such as Red-winged Lapwings, or Black-winged Stilts, Egrets and even House Crows when they came very near the nest. Even when a Marsh Harrier circled over low, the incubating Sarus registered no reaction. But when a Large Cormorant (*Phalacrocorax carbo*) alighted to fish near the nest of P12 with their newly hatched young, he was immediately driven away. Water buffalo roaming all over the Sanctuary posed a constant threat to the nests of the Sarus. If they came very near, they were threatened and warded off by parted wings, forward thrust beak and hissing. Instances of interaction between a Sarus and a Ring Dove and a Sarus and Pheasant-tailed Jacanas have already been noted. Sauey (this volume) discusses its behaviour towards Siberian Cranes (*Grus leucogeranus*).

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THE STATUS AND DISTRIBUTION OF THE BROLGA IN VICTORIA, AUSTRALIA

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ABSTRACT

Victoria is the southernmost breeding range of the Brolga in Australia. The distribution and abundance of this species has declined considerably during the last seventy years. The main habitats include fresh to saline swamps and lakes associated with open grassland and woodland, and to a lesser extent, river and billabong systems.

Between 1965 and 1981 152 active nest sites were recorded, along with another 46 locations where probable breeding occurs. The majority of nests occur in fresh water swamps. Man made dams are also used. Practically all wetlands used for breeding are on farmland. Locations where flocks of Brolgas gather during the summer and autumn have been recorded during the study period. Some of these locations are consistently used. A conservative estimate of the total Brolga population is 600 to 650 individuals. The drainage of wetlands since settlement in the 1840s has greatly reduced available habitat. The major remaining breeding areas occur in the higher rainfall areas of the southwest where grazing has been the traditional form of agriculture. In recent years there has been a change to more intensive agricultural practices such as cereal growing with a corresponding increase in the drainage of swamps suitable for breeding. There is a range of other problems that effect the population to a lesser extent. In view of the effect of changing agricultural practices, additional research and positive management strategies are needed to maintain a viable population of Brolgas in Victoria.

INTRODUCTION

The Brolga (*Grus rubicundus* Perry), is the only crane occurring in Victoria and the only crane indigenous to Australia. It is a large bird, quite conspicuous and easy to observe, although slightly smaller in stature than the Sarus Crane (*G. antigone sharpii* Blanford), which is now found as a breeding species in Northern Australia (Pizzey 1980). Parts of Victoria in which the Brolga occurs, are used for agricultural production, but minimal evidence of crop damage by the Brolga was reported during the study period.

Victoria is the smallest state on the mainland (230,000km^2) located in the southeastern corner of Australia (*Fig. 1*). Much of the state receives enough rainfall for intensive agriculture. Because Victoria is more densely populated than other Australian states, ecological changes could occur more rapidly in this state, threatening the future existence of the Brolga.

This paper gives data on the breeding distribution and flocking areas in Victoria, and describes some preliminary attempts at captive breeding of the Brolga. Several factors considered to be associated with an observed decline in the Brolga population are discussed.

FIELD STUDY METHODS

General information on factors effecting the ecology of the Brolga and the history of swamps used for breeding by Brolgas was collected at the time of field sightings and in the course of interviews with private landowners, amateur and professional ornithologists, officers of the Fisheries and Wildlife Division and members of game hunting organizations. The period of study was August 1965-December 1981.

Breeding sites were divided into two categories. The first included each individual wetland used as a breeding site, where I had observed eggs or small downy young. The second category included areas where I did not know the exact breeding location, but where eggs or flightless young had been observed and reported to me.

Most records made early in the study period related to nest sites in southwestern Victoria. Prior to 1978, information was collected on an opportunistic basis; regular visits to the field took place between 1978 and 1980. Additional data on sightings of flocks of Brolgas during the summer and autumn period, as well as information on breeding sites in northern Victoria was recorded. Some breeding sites in southwestern Victoria were visited several times throughout the breeding season to observe the start of egg laying and survival of young.

Some of the wetlands identified as nest sites had been the subject of detailed study by Corrick (1982). In view of this, the same classification and descriptive characteristics have been used in this paper.

In categorizing subadult birds, the descriptions used by Archibald (1974) were adopted. The descriptive terms were as follows:

Immature	- up to 10 months of age
Juvenile	- 11 months to 22 months
Young adult	- 23 months to pairing.

RESULTS

Former distribution and habitat. Early records indicate that the Brolga used to be more widely distributed and more common. In Victoria Brolgas were first recorded on the swamps and plains of the Melbourne area (*Fig. 1*) by the explorers Hume and Hovell in 1824 (Wheeler 1949), and breeding was recorded in the 1850s (Wheelwright 1861). Brolgas were frequently offered for sale as food at the Melbourne Market in 1899 (Campbell 1900), but by 1900, were rarely sighted on the plains just northwest of Melbourne (Wheeler 1949). Urbanization of Melbourne and the surrounding population areas, with the consequent destruction of practically all the wetlands, as well as hunting, contributed in a major way to the demise of the Brolga population close to Melbourne.

Brolgas occurred on French Island in Western Port Bay until 1919 (Andrew et al. 1981) and on the plains and wetlands of the Sale area until the 1920s (E. Lyndon pers. comm.). In the Rutherglen area in northeastern Victoria, small flocks used to be common (McEvey 1965) but these are now absent; the last attempted breeding there was in 1963 (A. McEvey pers. comm.).

Prior to the late 1920s Brolgas were poisoned and shot in large numbers in the Willaura and Darlington areas to deter them from digging up newly sown grain in the autumn (D. Laidlaw and L. Reading pers. comm.).

The large flocks of Brolgas of over 1000 individuals recorded to 1945 have disappeared and the areas that may have linked the southern flocks with the large populations of Northern Australia are now occupied only by small scattered groups around the remaining wetlands in New South Wales.

Thus in the past, the Brolga occurred on the coastal, volcanic and fluviatile plains of Victoria (Jenkins 1982) but was absent from highland areas and the dry aeolian plains of northwestern Victoria.

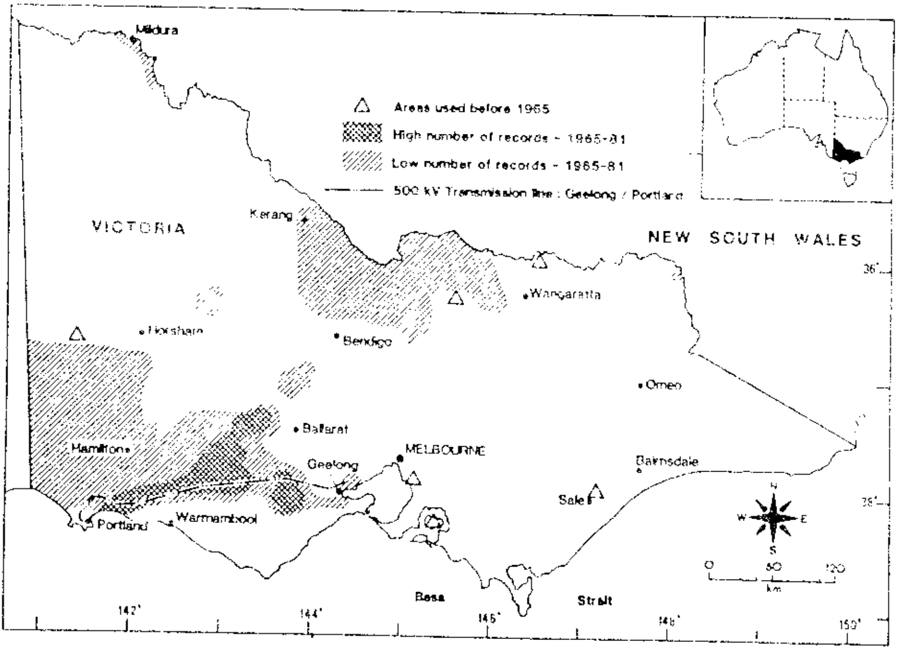


Fig. 1. Past and present distribution of the Brolga (*Grus rubicundus*) in the state of Victoria, Australia.

Current distribution and probable numbers. The current distribution of the Brolga in Victoria is shown in *Fig. 1.* Populations still occur on the volcanic plains of western Victoria where sheep and cattle grazing remains the main form of agriculture and some natural swamps remain. Brolga distribution falls mainly within the 400-700mm zones of average annual rainfall. Areas in northern Victoria have a lower average rainfall and, swamps do not fill every year to a suitable level for breeding.

More flocks of Brolgas were sighted in southwestern Victoria in 1978-81; this may have been the result of better breeding success during several years of higher than average rainfall, as well as increased effort in collecting information. At the same time the population of the introduced Red Fox (*Vulpes vulpes*), a reported predator of juvenile Brolgas, was lowered by more intensive hunting for pelts because of high pelt prices. In the 21 years the Serendip Wildlife Research Station has been operating, wild Brolgas visited in 1978, 1979, and 1980 and occasionally pairs were seen up to 25km east and just south of Geelong. The last recorded breeding in the Geelong area was in 1958 (Wood 1959).

Distribution of nest sites. Between 1965 and 1981 152 nest sites were located (*Fig. 2*). Evidence of breeding was reported for 46 other areas. The majority of known and currently used sites were on the volcanic plains of southwestern Victoria (117 sites or 76%). The remaining known and active sites were widely scattered throughout the range frequented by Brolgas, but there is little doubt that additional nest sites do exist. The marshlands along the Victoria-South Australia border between Portland and Edenhope were examined less frequently than other areas of the state, and nesting distribution could be more dense there. Additional sites have been recorded since 1981, but have not been included in the data presented here.

From the nest site records, it was not possible to determine the number of breeding pairs of Brolga remaining in Victoria, since some of these sites, which were recorded at the beginning of the study, have been drained or altered to make them unsuitable for breeding.

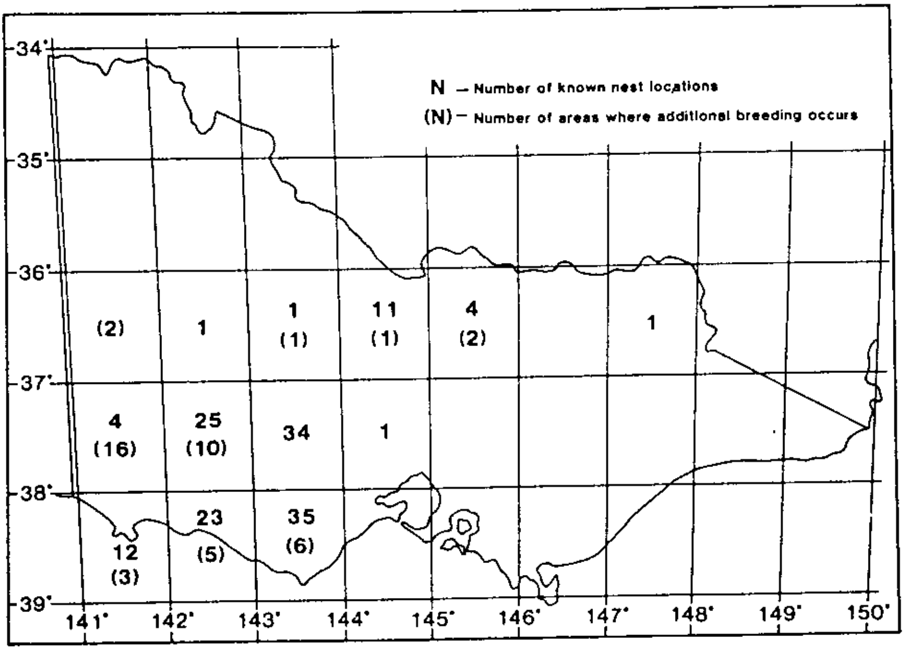


Fig. 2. Distribution of Brolga nest sites in Victoria by 1° latitude/longitude grids, 1965-1981.

Other sites have been used only once, or pairs of Brolgas may have alternated between different marshes, e.g. 16 known nest sites in the Skipton area are used by approximately 78 pairs that alternate between the sites depending on seasonal conditions (L. Millar pers. comm.). Of the total number of sites where Brolgas are known to nest, approximately five percent occur on public land.

Nesting density. Breeding territories from 3ha to 182ha per pair were recorded in North America in Greater Sandhill Cranes (*G. canadensis tabida*), and 259ha for Whooping Crane (*G. americana*) (Walkinshaw 1973). From my own field observations, Brolgas also appear to maintain substantial territories.

No more than one breeding pair was found on an individual wetland used as a nesting site during the study period.

Once a breeding territory has been established, pairs are capable of occupying the territory over many breeding seasons, as they are extremely long lived birds (up to 33 years in captivity, Lavery and Blackman 1969). Although the size of the territory maintained by each breeding pair of Brolgas may require that some pairs control more than one suitable wetland, nesting density appears to depend on the availability of suitable wetlands.

Selection of nest sites. Usually pairs of Brolgas appear in the vicinity of wetlands used for breeding during May and June. Nest building begins soon after swamps fill with water from the winter rains (June-August).

The characteristics of 48 of the wetlands used as nest sites during the study period, are set out in *Table 1* and *2*. These wetlands were situated between Port Phillip Bay and Mt Emu Creek (*Fig. 3*) at the eastern end of the volcanic plains. Shallow, herb dominated, freshwater marshes were most preferred (52%). Second preference was given to herb dominated meadows (25%). Man made freshwater impoundments constructed as watering points for sheep and cattle totalled 9 (19% of total). The impoundments used had

Typical nest in south western Victoria. Brolga tending newly hatched chick. *Photo. J. Pitchford*

well established vegetation in the shallow areas similar to that found in herb-dominated freshwater marshes.

Three wetlands used for breeding were drained during the study period and are no longer used. Four wetlands that had been partly drained prior to commencement of the study retained sufficient water in some seasons to remain attractive for breeding.

The selection of a wetland for breeding may depend upon how early it fills, water depth, and vegetation. Brolgas seem to prefer to wade to the nest site and build a nest surrounded by water. Shallow freshwater marshes and meadows provide sufficient depth of water to permit wading, and this situation also makes it difficult for predators to reach the nest site

Table 1. Characteristic depth and duration of indundation of freshwater wetland categories and typical vegetation of wetland subcategories of 48 nest sites within the study area between Port Phillip Bay and Mt Emu Creek.

Category	Depth (m)	Duration of indundation	Subcategories	Typical vegetation
FRESHWATER				
Meadows	< 0.3	4 months	Herb dominated	Annual moist soil species
Shallow marshes	< 0.5	6 months	Herb dominated	Annual moist soil species and aquatics
Deep marshes	< 2	12 months	Sedge dominated	*Lepidosperma longitudinale*
			Canegrass dominated	*Eragrostis australasica*
Permanent open water	> 0	permanent	Impoundment	Submerged aquatics with emergent species in the littoral zone[2]

[2] Depends on grazing

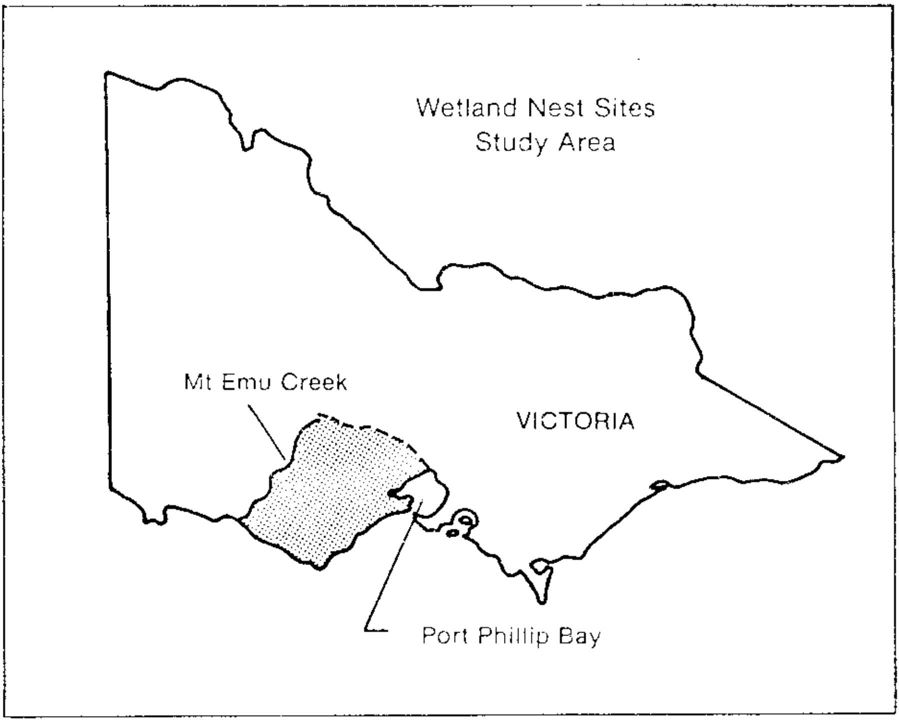


Fig. 3. Locality map of Brolga habitats between Port Phillip Bay and Mount Emu Creek.

without being observed. Some marshes are used for breeding every year that they fill; in one instance the same pair was observed to return to a particular site every year for twenty years (L. Millar pers. comm.).

Grazing by sheep and cattle severely reduces marshland vegetation during the summer and autumn. When marshes fill early, little vegetation remains for Brolgas to use for nest construction. I have seen nests contructed of clay and roots of marsh vegetation, dug from the bed of the marsh, when suitable vegetation was not available. The retention of vegetation from the previous season may be important to the Brolga when selecting sites for early nesting.

Table 2. Number of wetland breeding sites of each category and number of areas of each wetland subcategory in each wetland size range.

Category/subcategory	Number of wetlands in the following size (ha) ranges					Total number
FRESHWATER	5	6-10	11-25	26-100	100	
Meadow						
- Herb dominated	5	2(1)	4(1)	1	-	12
Shallow marsh						
-Herb dominated	9(1)	6(2)	6(1)	4	-	25
Deep marsh						
- Sedge dominated	-	-	-	1(1)	-	1
- Cane grass dominated	-	-	-	-	1	1
Permanent open water						
- impoundment	4	3		2	-	9
	18	11	10	8	1	48

Pair of brolgas on a typical small freshwater marsh used for nesting in south western Victoria. *Photo. P.Du Guesclin*

Flocking areas. From late December to early May Brolgas congregate at traditional flocking areas. This coincides with the drying out of shallow marshes in the breeding areas. A feature of these flocking areas is the availability of deep freshwater marshes for roosting and drinking.

Most information on flocking areas was gathered from verbal reports between 1978 and 1981. Flocking areas are indicated in *Fig. 4*; two major areas appear to be used. One area is Bool Lagoon, an extensive deep freshwater marsh in the southeast of South Australia, 30km from Victoria, shown on *Fig. 4*. The second is near Willaura where similar habitat is available. At Willaura, one flock of 1450 birds was counted during one autumn between 1939 and 1945 (S. Beggs pers. comm.).

At Bool Lagoon flocks of up to 200 were present during the late 1960s, with lower numbers in the 1970s and then an increase towards 200 in 1981 (H. Bakker pers. comm.). In recent years, up to 200 Brolgas have congregated at Willaura each summer and autumn except in 1968, when there was a drought (D. Laidlaw pers. comm.). During drought periods, the traditional areas may become unsuitable because deep marshes dry up. Six areas are used by smaller flocks (approximately 20 birds or more) regularly, and other, less frequently used areas have been reported. Since no Brolgas have been colour marked in Victoria one can only speculate that flocks at the two major flocking sites (Bool Lagoon and Willaura) originate from Victoria. Only low numbers occur in adjoining states, and the numbers in Victoria do not fluctuate greatly. It is therefore unlikely that a substantial interchange occurs between the northern and southern mainland populations.

On the same day in April 1980, counts were made at Bool Lagoon, Willaura, and Streatham, where flocks comprised 190+, 200 and 43 respectively. Later small groups were recorded at other locations while the main flocks remained stable. Not all Brolgas journey to the flocking areas; some breeding pairs with immature young remain close to their breeding areas. However, a conservative estimate of the total number of Brolgas remaining in Victoria would be 600-650 individuals based on the count of ± 450 at flocking sites and allowing for ± 100 remaining in small flocks and family groups in the breeding

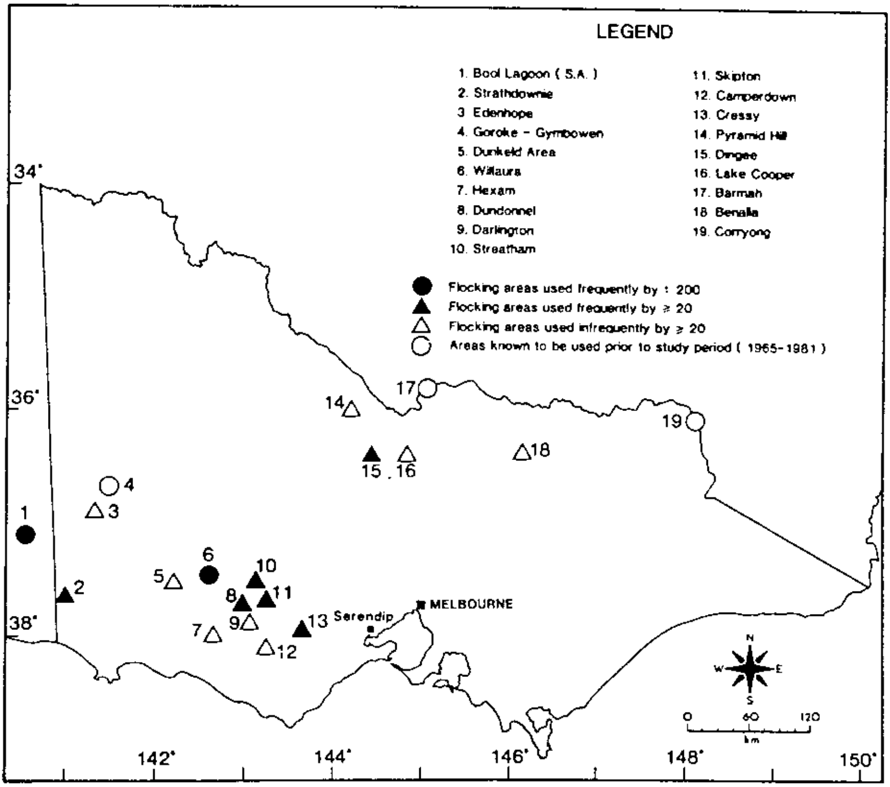


Fig. 4. Distribution of flocking areas used by Brolgas in Victoria.

areas of south-western Victoria. In northern Victoria the population could be as low as 50-100 individuals.

The age structure of the larger flocks has not been researched in any detail. During 1980 immature and juvenile Brolgas were present at Bool Lagoon, and it was estimated that these two age groups made up 10 percent of the total flock at Willaura. Juvenile Brolgas were identified by the absence of orange or red comb.

SEASONAL ACTIVITY

Feeding. Brolgas gather food by digging with their strong bills, and foraging in the shallows and on the edges of marshes. These activities may also take place on moist pasture and cropland during the wetter months. When the marshes dry from January to May, foraging includes residual grain left after crops have been harvested, insects, etc. Brolgas use a wide range of food including vegetable matter, seeds, tubers, freshwater molluscs, crustaceans, insects, small mammals, birds, and reptiles. Brolgas have some economic value to farmland by destroying pasture grubs, caterpillars, crickets, and grasshoppers. Brolga activity on an annual basis is represented in *Fig. 5.*

Breeding. Nests are usually constructed in shallow freshwater marshes and meadows, and eggs have been recorded from early July to mid-November. The nest is usually a substantial platform of vegetation, up to 1.5m in diameter. Sometimes eggs are laid on banks and islands with little or no vegetation supporting them. Of 31 nests examined, 21

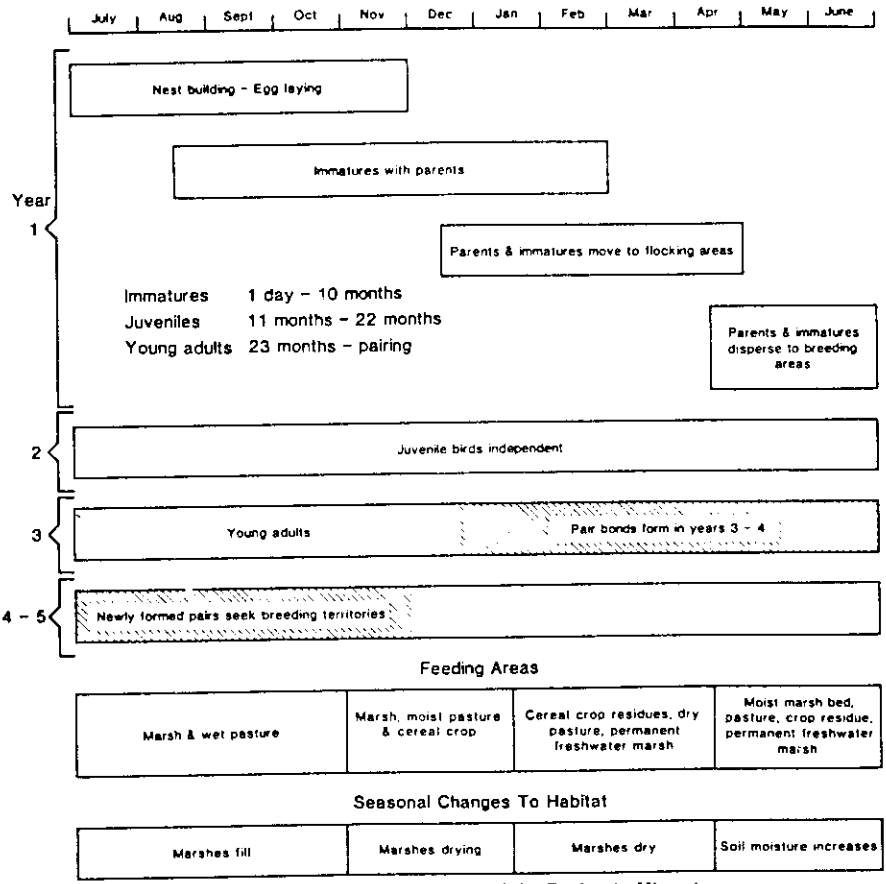


Fig. 5. Typical seasonal activity of the Brolga in Victoria.

contained two eggs (67%) and 10 contained one egg (32%). These were all complete clutches.

Thirty-seven eggs at all stages of incubation were weighed and measured. Average weight was 189g (R=160-210). Average length was 95mm (R=91-104), and average width was 63mm (R=60-66).

Both parents shared nest building, incubation, and rearing. Eggs hatch after an incubation period of approximately 31 days (Weber 1974). After hatching, parent birds move to the shallow margins of the marsh with their young to forage for food. Live food is crushed and killed before it is offered to the downy young. It is more common for one young to be reared than two. Forty-three different pairs with unfledged young were sighted during the study period, 33 pairs had one young (71%) and 10 pairs had 2 young (23%).

During the study period, Brolgas were found to be incubating swan eggs at two of the nest sites examined. One contained two swan eggs, the other one of each. The Black Swan (*Cygnus atratus*) and Brolga construct similar nests, often using the same marsh. It is therefore presumed that swans laid in the Brolga nest by mistake or the swan nest was taken over by the pair of Brolgas.

FACTORS LIMITING DISTRIBUTION AND DENSITY

Breeding success. The success rate from egg laying to fledging of young is difficult to assess, particularly since as the young develop, family groups spend more time away from the wetland used as nest site. Continued growth of vegetation obscures immature Brolgas, making observation difficult.

Fertility in wild birds could not be considered a limiting factor. Of 45 eggs taken for artificial incubation, 37 were fertile (82%) and 8 eggs (18%) were infertile. Brolgas are capable of laying again if eggs are lost, although pairs may continue to incubate infertile eggs for more than a month before abandoning them. When this occurs, it may be too late for a second laying, depending on seasonal conditions.

Three layings were achieved with one wild pair in 1979 by taking each clutch away as soon as laying was completed. This is standard practice with cranes in captivity.

Pairs often hatch two young, but frequently only one is reared successfully. Incubation usually begins when the first egg is layed, so the second egg hatches 1-2 days after the first. The first-hatched chick is usually stronger, more mobile, and more able to accept food. In captivity, hand-reared young are aggressive soon after hatching and will cause distress to a weaker chick, which may result in death. Reports from landholders indicate that the survival at some breeding sites is good, with two young being reared consistently, while at others the reverse is true. Seasonal conditions and the productivity of each nesting area and its surroundings must be an important factor in the survival of young.

Mortality. Mortality in Brolgas can be caused by a number of factors, many of these related to human activity. A number of causes were identified as a result of observations, interviews, and written reports received during the study period.

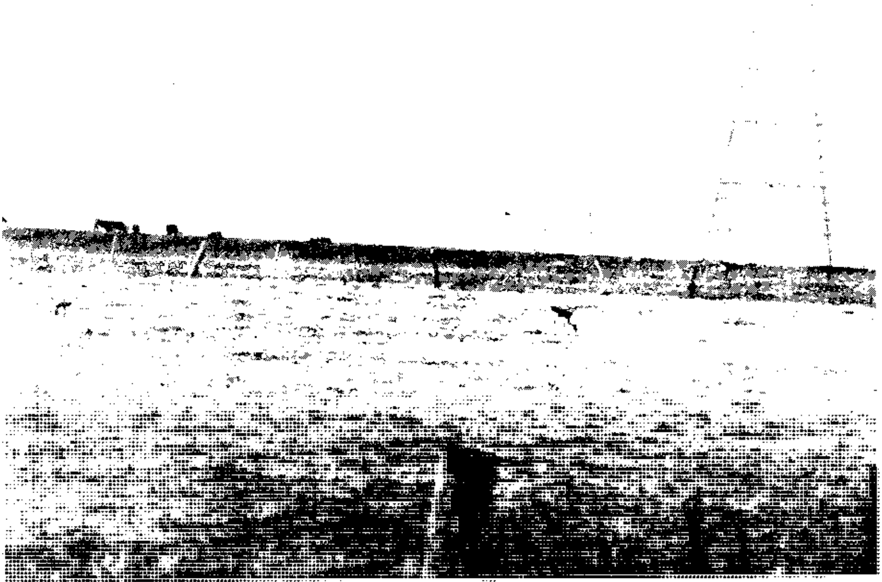
Losses of eggs were attributed to egg collecting, predation by Ravens (*Corvus* spp.), flooding of nest sites, and trampling by cattle, in that order of frequency. Egg collecting has gone out of favour as a hobby in recent years, but was widespread up to the late 1960s, and still occurs occasionally. Predation by Ravens, flooding of nest sites, and trampling by cattle do not appear to be serious problems. Losses of immature birds can result from predation by the red fox, from heing tangled in wire fences, capture for pets, or collision with vehicles or agricultural machines, in that order of frequency.

Information from private observers suggests that the fox is a significant predator, particularly where Brolgas are rearing young amongst thick vegetation in or around marshes or standing crops. In such habitat there is an opportunity for predation to occur before the fox can be observed and driven off by the parent birds.

Since the introduction of the European Rabbit (*Oryctolagus cuniculus*) in the last century, fences made of wire netting have been used as boundary and subdivision fencing on many large properties in Victoria. These netting fences can form a barrier to the movement of immature Brolgas if the marsh used for nesting dries out before the young fledge. Taking of immature Brolgas for rearing as pets has been practiced. Several cases were reported during the study period.

Death of fledged birds can result from collisions with electric power lines, fences, and vehicles, as well as shooting and poisoning. A number of collisions with power lines, resulting in death, have been recorded. The recently constructed 500 KV transmission line from Geelong to Portland passes directly through the best remaining breeding habitat in the state (*Fig. 1*) with at least fifteen known nest sites occurring along this power line route. Shooting and poisoning have caused significant mortality in the past. Reports of shooting are now less frequent. Illegal poisoning of ducks and cockatoos causing damage to agricultural crops continues, but it is difficult to assess the number of Brolgas poisoned as a non target species.

Availability of wetlands. Drainage has been one of the major factors in the decline of the Brolga population. Drainage of freshwater wetlands has continued since settlement. Corrick (1982) estimates that 79 percent of shallow freshwater marsh and 66 percent of deep freshwater marsh has been destroyed by drainage since European settlement in the area between Port Phillip Bay and Mt Emu Creek (*Fig. 3*). It is probable that similar amounts have been destroyed in other areas frequented by Brolgas.



Brolgas feeding beneath the 500 kV power line recently constructed across south western Victoria, bisecting the major Brolga breeding areas and posing a serious threat to their future. *Photo. D. White*

Aerial photograph depicts how Brolga breeding habitat along the shallow Piccininny Creek floodplain in northern Victoria was recently destroyed, firstly by levee banling the edges to provide more land for grain growing and finally by channelizing the stream. *Photo. D. White*

Small shallow freshwater marshes, the most important for breeding, are under constant threat from drainage as cereal growing is extended into areas traditionally used for grazing. In northern Victoria, rainfall is lower and breeding opportunities are fewer, as wetlands fill less regularly than in the south. For nesting sites, Brolgas have relied on shallow freshwater meadow, large freshwater marsh systems, floodplains and wet areas caused by leaking irrigation structures and irrigation drainage areas. Agricultural land is becoming more intensively managed, drained and levelled for irrigation to incorporate engineered drainage basins for the reuse of water and more efficient irrigation structures that eliminate loss of water. Rivers are deepened, desnagged, and altered, while large storage dams are reducing flood frequencies. Small streams are canalized, levee banked, and changed to drains unsuitable for wildlife. Breeding sites are now fewer except in abnormally wet seasons. The salt problem associated with irrigation in northern Victoria is destroying freshwater marshlands that once formed suitable nesting sites for Brolga. Larger farm dams are constructed, and these may be suitable for nesting if suitably designed with sufficient shallow areas and well established vegetation.

CAPTIVE MANAGEMENT AT SERENDIP WILDLIFE RESEARCH STATION

Brolgas have been kept at Serendip since 1964. Work on artificial incubation and captive rearing was initiated to establish a captive flock of known-age birds. Eggs already incubated were collected from pairs in the wild in western Victoria. During 1965-1966 a total of 24 eggs were collected, and an additional 20 eggs were taken during 1978, 1979, and 1980.

Incubation and Rearing

1965-1966. From the first 24 eggs, 13 hatched (54%) and 9 chicks were reared successfully to fledging stage (69% of those that hatched). Post hatching mortality was due to leg deformity (2 chicks), interchick fighting (1 chick) and injury (1 chick).

Incubation was carried out in still air and forced air incubators, with eggs being turned manually twice daily; otherwise, incubation methods were similar to those described later for the 1978-1980 period. Food consisted of lean minced meat impregnated with 'turkey starter' pellets (24% protein) during the early stages of rearing, and resulted in high growth rates. Leg deformities occurred in two chicks.

1978-1980. From 20 eggs, 14 hatched (70%) and 13 chicks were successfully reared to fledgling (92%). The single post hatching death occurred when a 65 day old chick was bitten by a Tiger Snake (*Notechis s. scutatus*) that entered the rearing facility. Overall results from the Serendip programme are shown in *Table 3*.

Table 3. Incubation and rearing results for eggs collected from wild pairs.

	1965	1966	Total	1978	1979	1980	Total
No. of eggs	6	18	24	7	9	4	20
Infertile	-	4	4	2	1	1	4
Failed to hatch	2	5	7	-	2	-	2
Hatched	4	9	13	5	6	3	14
Post-hatch mortality	2	2	4	1	-	-	1
Reared to fledging	2	7	9	4	6	3	13

Current techniques used at Serendip for incubation and rearing were developed independently, but are similar to those used at the International Crane Foundation (Archibald & Veiss 1978, LaRue & Hoffman 1981). Incubation and rearing equipment and facilities had already been developed for the Australian Bustard (*Ardeotis australis*), and these were found to be adequate for Brolga during 1978-1980.

Brolga eggs are incubated at a temperature of 37.5°C dry bulb, and a wet bulb temperature of 32.5°C. Small, glass topped, forced air incubators are used, each with a capacity of 6-8 Brolga eggs. Eggs are placed horizontally in the incubator and turned automatically by rolling through 180° at hourly intervals.

Turning is discontinued five days before hatching or when pipping is observed. Eggs are then transferred to a hatcher at the same temperature and humidity setting. After hatching chicks remain in the hatcher for 8-12 hours to dry off before being transferred to the brooder room.

1-2 days of age. Each chick is placed in a small brooder box (dimensions 30cm x 27cm x 27cm high). A thin sheet of foam plastic is placed on the floor of the brooder box to provide a nonslip surface. A temperature of 37.5°C is maintained using clear carbon heat bulbs (240V x 115V).

The average weight of 14 chicks hatched at Seredip was 124g. A loss of weight in the first five days was recorded, 114g. heing the average weight of 14 chicks on the fifth day.

Each chick is fed 50 percent lean minced meat impregnated with 50 percent powdered 'turkey starter' crumbles (24% protein) 4-6 times daily using tweezers to offer food. Little food is taken until the second day. Water is provided with an eye dropper 3-4 times per day, and meal worms are provided to stimulate pecking.

3-10 days of age. Each chick is housed in a circular enclosure made of galvanized steel sheet, 30cm high and 1.5m in diameter. The floor is covered with fine sand 5cm deep and a sheet of foam plastic is placed under both the heat source and food receptacles. To minimize imprinting, perspex windows are connected to adjacent enclosures to allow each chick visual contact with others. Similar heating is provided using small hanging brooders that can be adjusted to suit the growth of the chick.

The maintained ambient temperature is reduced after 40 days and heating is eliminated after 60 days, depending on the outside ambient temperature.

A damp mash is made using water and a mixture of 45 percent 'chicken grower' crumbles (15% protein), 45 percent 'turkey starter' crumbles (24% protein) and 10 percent alfalfa meal by weight. The damp mash is set out for each chick, as it is more easily picked up and swallowed. By the third or fourth day, the chick is usually feeding itself quite well and from then on a dry food mixture is used until each chick is 70-80 days old.

Additional supplements are fed twice a week including multivitamin concentrate, manganese chloride (to prevent perosis) and calcium glucinate (for bone structure). Water and grit are always available.

11-16 days of age. A larger enclosure (1.5m x 3m x 30cm high) within the brooder room is used with similar management, before young birds are transferred at seventeen days to outdoor grassed runs (1.5m x 12m). The outer sides of this rearing facility are lined to 1.5m, to provide protection from wind. All weather shelter is provided at one end. The portion of the run available to each chick is increased as it grows in size. Brolga chicks can be run together after 40 days if introduction is done gradually; aggressive birds must be watched carefully until compatible.

Average growth rate for Brolgas reared to 60 days is shown in *Fig. 6.*

Brolgas are fully feathered between 80-90 days and fledge at 90-100 days. Body weight at fledging ranges from 3.5-5kg. Retrospective analysis of records indicates that males can be approximately 1kg heavier than females at fledging.

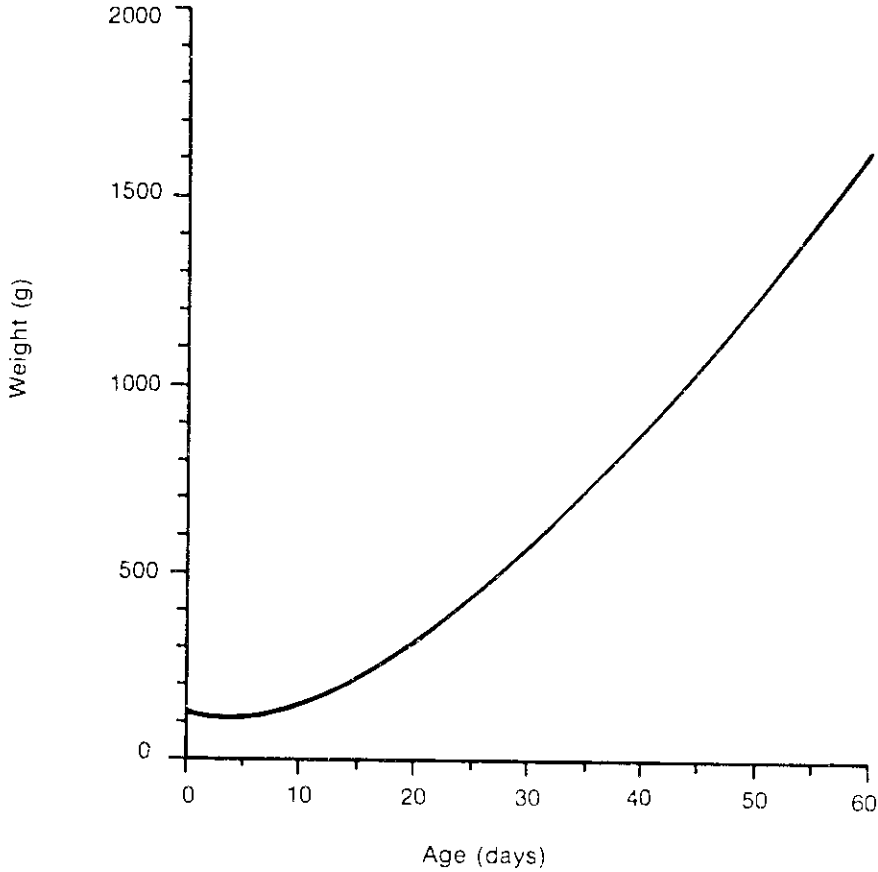


Fig. 6. Growth curve for six Brolga chicks reared to sixty days.

Management. Immature Brolgas were kept together in a large 0.8ha enclosure after 60 days of age, and then remained as a flock until pairbonds were formed at 3-4 years. Alternatively young adults were placed separately in smaller adjacent enclosures that allowed visual contact; when pair bonds were formed, birds were placed together permanently. Both methods have been used at Serendip. A flock of juveniles or young adults in captivity may not accept new birds, and care must be taken to introduce new birds gradually.

Brolgas at Serendip have remained free of disease, and appear to be extremely hardy in captivity. The major cause of death in the early years of captive work resulted from the hierarchy developed by pairs within a large enclosure, resulting in the killing of several Brolgas by a dominant male. Deaths also resulted from attempts to form pairs where the sex of the birds had not been correctly identified. Details about the cause of death following fledging of Brolgas reared at Serendip is shown in *Table 4*.

During 1980 a wild male Brolga took up residence at Serendip, killing a paired captive male to form a pair bond with the female.

Successful breeding from captive pairs has not occurred at Serendip, due partly to the lack of suitable enclosures for breeding pairs. Three large adjacent enclosures, each 0.8ha,

Table 4. Causes of death in order of frequency for eight deaths, from 22 Brolgas hand-reared during the study period.

Cause of death	Number of losses
Other Brolga	3
Injury	1
'Peritonitis'	1
Kidney degeneration	1
Predator	1
Unknown	1
Total	8

were used with no visual barriers dividing pairs. Artificial insemination has not been attempted at Serendip.

From about 70-80 days of age, immature Brolgas are fed a maintenance diet of 'grower pellets' (15% protein) and wheat until pairs are formed. Adult pairs receive a similar maintenance diet in the nonbreeding period. Throughout the breeding season the diet is changed to provide a 20 percent protein level. Enclosures are large enough to provide some foraging for pasture grubs and insects.

Breeding facilities for adult Brolgas. A new complex covering 0.8ha was completed in 1980, and now houses nine pairs. The ten enclosures are each 13m x 56m separated by a 2m wire netting fence clad to a height of 1.3m with galvanized steel sheet as a visual barrier. Published data on crane management techniques at the International Crane Foundation (Archibald 1974) have influenced the design of the breeding enclosures. Each enclosure contains a small marsh area 10m in diameter with a small island 2m in diameter. Food is located in a moveable, height adjustable waterproof self-feeder, and drinking water is provided independent of the small marsh.

The only release of a hand reared bird occurred in December 1973 in the Corryong area of northeastern Victoria to assist the small remaining population.

The Brolga used was orphaned when its parents were killed by a train. When orphaned, the Brolga was six weeks of age; it was released at 12 months of age. It still remains in the area (L. Reiner pers. comm.). Modifications would be required to facilities used for hand rearing Brolgas for release into the wild, to eliminate visual and physical contact with people, so that successful releases could be achieved.

CONSERVATION MEASURES

Brolga numbers and range in Victoria have been reduced as a consequence of European settlement. The greatest impact occurred from the 1890s to the late 1940s, when the majority of wetlands were drained and major irrigation projects were completed. At the same time, poisoning, shooting, the erection of netting fences, and other causes took their toll. Brolgas still breed, mainly in areas of less intensive agriculture, where suitable marshlands still remain, or water impoundments have been constructed that fulfill their requirements. Impoundments are more likely to be used for breeding where a shortage of natural marshland occurs.

In recent years a large number of private farms have been sold. Often the new owners are unaware of the importance of marshland on their farms as nesting habitat for Brolga. Changes to the property under new ownership are often directed towards more intensive agricultural management, and may include the drainage of marshland to obtain additional agricultural production. During the study some owners indicated their interest in retaining marshlands after its importance as habitat for Brolga had been explained. Most landowners showed interest in retaining Brolga on their properties and were very cooperative in supplying information.

To conserve the Brolga population throughout its existing range it is essential that existing breeding habitat be retained and potential habitats improved. The size of the Brolga population is not known accurately; it varies from reasonable numbers of breeding pairs in a relatively small area of the volcanic plains in southwestern Victoria, to quite low numbers in other localities within their breeding range. Little is known about the survival rate of young and whether the recruitment of young birds is sufficent to maintain the existing population. Flocking areas may play an important role in the survival of a viable population, as the wetlands and surrounding feeding areas support the birds through the drier months.

It is possible that young adult birds form initial pair bonds at these flocking areas. Immature and juvenile birds may then disperse as separate flocks prior to the breeding season, when they become more independent.

The illegal use of poisons to kill birds that damage agricultural crops poses a serious problem at each major flocking area, where possibly 33 percent of the total population of Brolgas gather and would be susceptible as a nontarget species.

The following measures are thought necessary to maintain adequate populations of Brolgas in Victoria.

- As many breeding sites as possible should be identified and classified according to their importance. This weuld be based upon local density, regularity of usage, and yearly production. This could be achieved by a combination of ground and aerial surveys.
- Increased public education about the importance of wetlands for Brolga, directed towards landholders in particular.
- Provision of financial incentives for private landowners to maintain or create appropriate wetland habitat for the Brolga.
- Introduction of specific legislation hy the Government of Victoria to protect the wetland areas from alteration or destruction.
- The establishment of a continuous monitoring programme to determine the accurate size and structure of the Brolga population in Victoria and its movements as well as the impact of agricultural practices on the breeding success and the long term survival of the Brolga in Victoria.
- The Serendip Wildlife Research Station should operate as a production unit for Brolgas that could then be released into selected areas of northern Victoria to maintain the small existing population found there.

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CHAPTER II

EDITORS' INTRODUCTION: SIBERIAN CRANES

The International Crane Workshop convened at Keoladeo National Park in the State of Rajasthan, near Bharatpur, India, because the central Asian flock of Siberian Cranes winters on the shallow wetlands in the park from November through March. Throughout much of Rajasthan, animals are strictly protected by the Hindu faith. Adaptable species such as Sarus Cranes flourish, while ecologically-specialized species like the Siberian Crane are endangered in this densely populated nation where much of the natural landscape has been transformed by agriculture. The lush habitat within Keoladeo National Park, coupled with the values of the local people, however, blend to produce one of earth's great wildlife spectacles, the crown of which is the remnant flock of Siberian Cranes. Although Siberian Cranes are well-known birds, many gaps in their basic biology were not revealed until recently.

In the mid 1970s Ronald Sauey made the first comprehensive study of Siberian Cranes on their wintering grounds in India. In 1978 Mohammed Ali Ashtiani re-discovered a flock of Siberian Cranes wintering on the Caspian lowlands of Iran. In 1981 Alexander Sorokin finally located the nesting grounds of the central Asian flock near the mouth of the Ob River. That same year Zhou Fuchang and Deng Wenning located the wintering grounds of the east Asian population at Poyang Lake in Jiangxi Province. And in 1981 Siberian Cranes bred for the first time in captivity. All these historic developments are presented in this chapter.

Breeding exclusively in the wild in the USSR; breeding in captivity in the USA; wintering in Iran, India and China; migrating over Afghanistan, Pakistan and Inner Mongolia; and threatened by hunting and habitat loss, the Siberian Cranes' security is better assured if international cooperation in conservation could be promoted. Consequently, the International Union for the Conservation of Nature is striving to develop and promote a Siberian Crane Agreement, whereby signatory nations agree to participate in studying and saving the Siberian Cranes and their fragile habitats throughout the enormous range of these migratory birds.

In 1983 participants at the International Crane Workshop estimated that about 350 Siberian Cranes survived in the wild in three widely-separated populations: 10-15 birds in a western population that winters in Iran, 35-40 birds in the central population that migrates to India, and 230 birds in the eastern flock that winters in China. During the past four years, the western and central populations have remained stable. In 1985, however, as many as 1,350 Siberian Cranes were counted at Poyang Lake Nature Reserve, China. Apparently Siberian Cranes from other regions of southern China are congregating at Poyang Lake as a consequence of the recent protection from hunting. This recent discovery of so many Siberian Cranes in the eastern population brightens the future for an unusual crane that is known as the "Snow Wreath" in the USSR and the "Crane with Black Sleeves" in China. The Siberian Crane has become a vehicle for international cooperation and good will.

SIBERIAN CRANE AS A WINTERING BIRD IN IRAN

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ABSTRACT

In 1978 the Siberian Crane (*Grus leucogeranus*) was rediscovered in the south Caspian region of Iran where it had not been recorded for approximately 60 years. Since 1978, 7-14 birds have been reported each winter at Fereydoon Kenar. The wetlands used by Siberian Cranes are traditional duck hunting areas in which other birds are fully protected by both tradition and government regulation. The Government of Iran wishes to cooperate with other nations sharing the Siberian Crane to develop a program of crossfostering Siberian Cranes with Common Cranes (*Grus grus*).

INTRODUCTION

The Siberian Crane (*Grus leucogeranus*) formerly occurred in winter in the south Caspian region and, according to Zarudniy (1911), in Sistan (southern Iran). Caspian records are summarized in Schuz (1959). The last record in the south Caspian region was at Lenkoran, USSR, in 1925. The first sighting of the Siberian Crane in Iran after about 60 years was made in mid-January 1978, at Fereydoon-Kenar in the course of midwinter wildfowl counts. Since 1978, a group of 5 to 14 Siberian Cranes has wintered at Fereydoon-Kenar, in the south Caspian region. The number of birds seen was recorded as shown in *Table 1.*

The Siberian Crane is a truly endangered species (world population less than 1500 individuals), but fortunately it has become reestablished naturally as a winter migrant in Iran. The Islamic Republic of Iran has felt deep concern for the conservation of all wetlands and waterfowl in Southwest Asia. The Department of the Environment has determined that among the rare birds in Iran, the Siberian Crane requires special and immediate attention.

FIRST SIGHTING, HABITAT, AND POPULATION

The first sighting after about 60 years was made in 1978 by the author and Mr. Behrooz at Fereydoon-Kenar in mid-January during the midwinter waterfowl counts. Two Siberian Cranes were seen in the Damgah (commercial wildfowl trapping site) approximately 1km SE of the town. On 6 February 1978, we returned to the site to make further observations and attempted to photograph these birds. They were found again at the same place. Even at a range of 500 meters it was obvious that they were definitely Siberian Cranes. With the help of local guides, we approached the birds much more closely under the cover of the trees of the Damgah; and photographs were taken with 400 and 600mm lenses. The birds were unaware of our presence and were left undisturbed. An attempt was made on 7 February to obtain closer views of the cranes for photography. The birds were found in an empty rice field next to the end of the row of trees and were approached to within 150m. A few photographs were taken and later the cranes flew off from the Damgah. At this point it was noted that their call was similar to that of the Common Crane (*Grus grus*) with which both of the observers were familiar, however it was thought to be more musical. In the afternoon, the Siberian Cranes returned to the rice paddies and an approach was made from another direction along a ditch. This proved to be very successful and photographs were obtained from 80m.

The following day, 8 February, we went to check on rumours of more Siberian Cranes at the eastern end of the row of trees. First, the two known birds were seen in their usual place at the western end of the row, and then a search was made from some of the observation points to the east. While the observers were taking photographs of other wildfowl at the eastern part of Damgah, a group of 5 Siberian Cranes walked out from a blind spot in a curve in the reed wall and were photographed from a distance of about 30m without any disturbance.

Almost continuously during the time of observation, the cranes were seen to be feeding actively. Tubers of a sedge (*Cyprus rotundus*) were eaten. The cranes foraged by submerging their head and necks to pull out the roots and tubers, which are their dietary mainstay throughout the winter. The cranes seemed generally to be quite social, roosting and feeding in close small flocks, frequently in a group of 3 to 4 within the flocks of Greylag Geese (*Anser anser*). According to Archibald (1975) the geese serve as alarm detectors for the cranes. As Archibald has indicated in his research proposal concerning the identification of potential Siberian Crane habitat in Iran, "Open shallow water, the presence of submergent sedge vegetation, and the presence of Greylag Geese, are the primary ingredients of the presence of the winter habitat of the Siberian Crane." This situation has been observed at the Siberian Crane habitat of Ferydoon-Kenar.

The local trapping operations of the Damgah near Fereydoon-Kenar involve only ducks, mainly of the genus *Anas*, and therefore the cranes are in no danger from the trapping. Rather, the reverse is true: the cranes and other wildfowl such as geese, herons, and pelicans receive some measure of protection within the rice paddies of the Damgahs. This is because the trapping areas are rented to local people by the Department of the Environment, and since the trapping methods rely on the areas being rigorously guarded, absolutely no disturbance to the Siberian Cranes and other wildfowl is expected. The renters take great care to protect their area from other hunters, and shooting is completely prohibited in the Damgah.

In recent years local people have reported between 8 and 14 Siberian Cranes in the area from October to mid-March. The number of Siberian Cranes reported by the personnel of the ornithology unit since 1978 is shown in *Table 1.*

Table 1. Numbers of Siberian Cranes observed at Fereydoon-Kenar, south Caspian region.

Year	Number
1978	11
1979	-*
1980	-*
1981	8
1982	5
1983	7

* no observations were made

CONSERVATION

In consultation with the International Crane Foundation, the Iran Department of Environment has established a long term research and conservation project on the Siberian Crane. In addition, efforts are underway to enlist the cooperation of neighboring countries that also harbor this rare bird. It is clear that the future of the tiny Iran population depends on a close monitoring of this species' numbers and habitat use and its continued protection by local villagers.

In the more distant future, it may be possible to augment the numbers of cranes wintering in Iran through a reintroduction project involving cross-fostering with the Common Crane (*Grus grus*) (Archibald 1975). Such a plan would require more knowledge than currently available of the Common Crane's migration routes and nesting habitat.

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HUNTING PRESSURES ON CRANES MIGRATING THROUGH PAKISTAN

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ABSTRACT

Limited information is available about the spring and fall migrations of Common Cranes (*Grus grus lilfordi*), Demoiselle Cranes (*Anthropoides virgo*), and the Siberian Crane (*Grus leucogeranus*) through Pakistan. The Indus Valley forms an important flyway for these birds. Efforts to begin monitoring migrations are now being encouraged.

Although published reports speculate that Common and Demoiselle Cranes migrate through Pakistan in great numbers, fact finding visits to the North West Frontier Province (NWFP) in December, 1981, and October, 1982, reveal that crane hunting by Pathan tribesmen near Bannu in the Kurram Valley may have significantly depleted crane populations migrating through the region. Decreasing success in the Kurram Valley has caused crane hunters — numbering as many as 1000-1200 men — to turn their attention to alternate areas in Baluchistan and the Punjab. The implications for the endangered Siberian Cranes of this growing fad are considerable.

The total yearly take for the three groups is estimated at 1500-2000 birds (divided almost equally between the Common and Demoiselle Cranes). Most of these birds are kept or given to friends for training as decoys for future hunting. A smaller number are sold for commercial purposes. The remainder are eaten in the field. The investigators saw many semidomesticated cranes wandering along the roads and fields of Bannu, NWFP. Two pairs of Demoiselle Cranes were seen to have reproduced in captivity.

Proposals have been made for: a census of captive cranes; a study of ways to increase the breeding of captive birds; establishing bag limits for the hunting of other cranes — especially in the spring; protecting the Siberian Crane through provincial laws; exploring the feasibility of inducing hunters to colour mark and release some cranes; educating the various constituencies about threats to the survival of the Siberian Crane posed by the hunting.

INTRODUCTION

Three crane species migrate through Pakistan in the spring and autumn en route to wintering grounds in India: Common Cranes (*Grus grus lilfordi*), Demoiselle Cranes (*Anthropoides virgo*), and Siberian Cranes (*Grus leucogeranus*). The Common Cranes migrate south from breeding areas in central Asia east of the Ural Mountains and in western Siberia. Breeding groups of Siberian Cranes were recently located along the wetlands of the Ob River basin (Freeman 1981). The Demoiselle Cranes also breed in central Asia. The Indus River Valley appears to be the main migration route for all three species. None of these species are year round residents of Pakistan.

METHODS

The information for this paper has been gathered informally; it is not the product of a systematic study of crane migrations. However, Roberts has lived in Pakistan much of his adult life and has actively observed wildlife there for over three decades. He happened upon crane hunting in the North West Frontier Province while discharging duties as an FAO crop protection advisor (Roberts 1977).

As a consequence of his attempts to investigate the validity of the common assumption that Siberian Cranes were migrating nonstop from the Keoladeo Ghana Bird Sanctuary in Bharatpur, India, to Lake Ab-i-Estada in Afghanistan, Landfried began investigating crane migration through Pakistan in 1980. With financial assistance from the U.S. Fish & Wildlife Service, he traveled to Peshawar in the NWFP during December, 1981, to interview a long time crane hunter from the Kurram Valley and to talk to conservationists, hunters, and governmental officials.

As a consequence of this information, the authors traveled together to the NWFP at the end of the autumn 1982 hunting season. At that time we visited a crane camp, interviewed 8-10 crane hunters, observed the condition and behaviour of dozens of captive, pinioned cranes in the Bannu area, and discussed alternative strategies for minimizing the potential impact of the crane hunting on all three species, but particularly the Siberian Crane. However, because of the lateness of the season, we were unable to witness the capturing of any cranes.

In short, this report is based largely on first hand accounts of cranes. The existent literature has provided some useful background, but relatively little current information.

CRANE MIGRATIONS THROUGH PAKISTAN

Because no detailed studies of crane migrations through Pakistan have been conducted, information about the seasonal passages is minimal. Published reports are extremely dated and probably provide a very unrealistic impression of the present state of affairs. Early this century vast numbers of Demoiselle and Common Cranes were observed on migration (Baker 1929, Whistler 1949). Reports of enormous numbers in the late 1960s are partly based on these earlier reports (Ali & Ripley 1969), since little current information was available. Present evidence is that flocks seen in Punjab and Sind Provinces over the last decade reach maximums of 200 to 300 birds, but most frequently less than 100 birds. We surmise that Common and Demoiselle Cranes wintering in the subcontinent have declined considerably more rapidly than is generally recognized.

Although Cramp et al. (1980) state that Pakistan and India are the main wintering quarters of the Common and Demoiselle Cranes (Cramp et al. 1980), little evidence exists of Common Cranes wintering in Pakistan. Some Demoiselle Cranes appear to winter near Sibbi and along the Rann of Kutch (Landfried 1983).

The primary entry point in the autumn for Common Cranes migrating into the subcontinent is the Safed Koh (also called Koh-i-Safed) range at the extreme southwest corner of the great Himalayan barrier. Descending down the Kurram River valley to the Indus in the Mianwali District, most proceed toward the Indus delta and fan out southeastwardly across the Rann of Kutch. Some Common Cranes, however, fly down the Chenab River valley. There are no records of any significant migration of these birds west of the Indus in Baluchistan (*Fig. 1*).

The Demoiselle Cranes appear to disperse more widely in their migration through Afghanistan. Considerable numbers cross northern Baluchistan as well as the Safed Koh Mountains and the Kurram Valley. After reaching the Indus River, they tend to branch off into the southern Punjab and disperse in a southeasterly direction through the Cholistan Desert and into Rajasthan.

To our knowledge, there have been no ringing recoveries of these two crane species wintering in the subcontinent. However, the conspicuousness and highly audible nature of

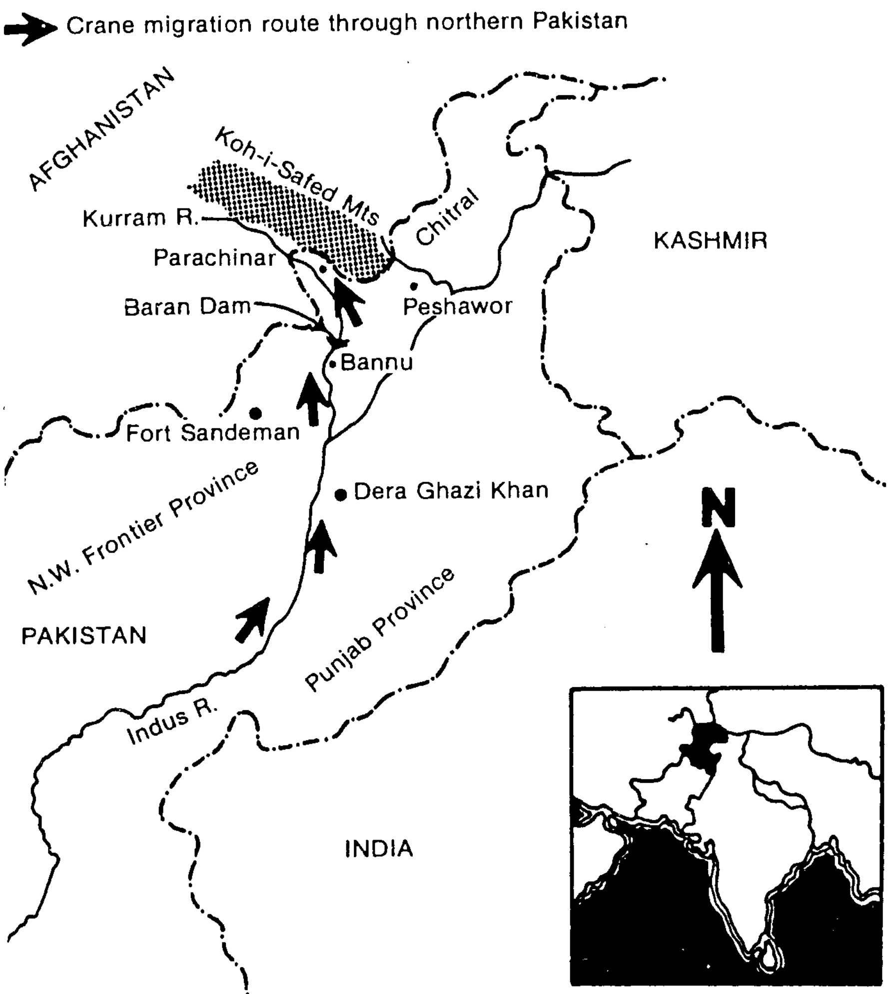

Fig. 1. Crane migration route through northern Pakistan.

their presence allows bird watchers generally to confirm the birds' faithful adherence to the patterns described — and to lament their steady drop in numbers.

Virtually nothing is known about the migration of Siberian Cranes through Pakistan. Claims of a Siberian Crane presence in Pakistan are based on old citations (Ali & Ripley, 1969).

Avid ornithologists, mostly British, working during the 1960s and 1970s in the Indus basin, saw no Siberian Cranes; nor did teams of ornithologists conducting systematic wetlands surveys for the International Waterfowl Research Bureau (IWRB) from 1968 to 1974.

The first reported sightings of Siberian Cranes in decades come from conversations with two long-time Kurram Valley crane hunters; one of them reported seeing Siberian Cranes as recently as 1978/79 in the air and on the ground and in the 1960s had seen three Siberian Cranes caught and eaten by friends (Landfried, 1982).

CRANE HUNTING IN THE NORTH WEST FRONTIER PROVINCE

In addition to habitat destruction of breeding grounds in the Soviet Union caused by drainage of wetlands and increased agricultural activities, hunting pressures in Afghanistan and Pakistan are an important cause of the apparent decline of Common and Demoiselle Cranes migrating to the Subcontinent. In light of the relative lack of disturbance to their breeding areas, hunting may also have been a primary factor in the precipitous drop in Siberian Cranes wintering at the Keoladeo Ghana Bird Sanctuary in Bharatpur, India (down from 77 birds in 1972 to 35 birds in 1983).

Unlike Afghanistan, where cranes are shot, hunting in Pakistan usually involves the live capture of the birds. Decoyed at night during migration by the calling of captive cranes in cages, the birds are snared by Mahsud and Wazir Pathan tribesmen, who simultaneously throw weighted cords (known as *soia*) as much as 30m into the air. Because of the wary nature of the birds, hunters have the greatest likelihood of success on extremely dark or stormy nights.

While one might think this seemingly primitive approach would bear little fruit, the considerable patience and skill seem to overcome the odds, and many parties average 100 crane catches a year. More than one source reported that bags in Baluchistan have exceeded 300 birds. With crane hunting having spread outside of the NWFP, it appears no less than 1500 cranes were caught in this manner during 1982.

Although the success of a crane hunt is dependent on weather, location, and the skill of the throwers, perhaps the most important element is the captive decoy birds. Hunters actively seek captive birds of opposite sex with a proclivity for especially loud unison calling. The demand for these birds is so great that several sources have reported such pairs selling for as much as 20,000 rupees (approximately US$1600) — quite an amount considering that per capita income in the area is around US$350.

The spring crane hunting begins around the first of March and continues until early April; the autumn hunting runs from early September to mid-October. At the beginning of each hunting season, birds selected as decoys are placed into 3x4 foot cages. About 5 feet high in the middle, cages are made of branches of a local tree *(Tamarix doicia)* which are spaced about two inches apart and crosshatched with fish netting. On some occasions, two cranes are put in the same cage.

The cages and the decoy birds are transported by bullock carts or colourfully decorated trucks or buses to the semidry gravelly river beds along which the migrating cranes are known to migrate, or to the small islands at the north and west ends of the lake at the Baran Dam near Bannu.

The hunting parties consist of 10-25 men and boys who leave their work in the late afternoon to go to nearby camps. Those who travel to Baluchistan leave families and jobs for up to five weeks to engage their passion for this sport. Each group brings 8-12 pairs of caged cranes with them as decoys. Some hunting areas in the Kurram Valley are apparently assigned for generations to specific tribal villages; others operate on a first come, first served basis.

Once camps have been established, the hunters take the decoy cranes a short distance from the tents or thatched huts. Each night the hunters await their prey. When the reactions of their decoy cranes indicate passage of wild cranes overhead, hunters spring into action, running to arrange themselves in a row of 8-20 individuals ready to throw their *soia* at a moment's notice, on the comand of their leader.

The wild birds spiral cautiously down toward the calls of the decoy cranes. As they are about to land, the hunters twirl the *soia* in unison and silently hurl the wieghted cords skyward. With 6-7 foot wingspans fully extended, the cranes make rather large — albeit dark — targets. Hunters report that whenever the cord wraps around the bird's neck, the cranes are usually able to escape. However, when the cord entangles a wing, the bird immediately senses something is amiss and quickly descends. Slack is allowed in the line to facilitate the bird's safe landing.

Once the bird is on the ground, another hunter runs forward swiftly to capture the bird. At some risk from the angry crane's rapier-like bill, he overpowers the bird and cuts, pulls, or breaks the flight feathers before whisking it off to a nearby hut or tent.

Apparently crane hunting has become quite popular in the last 4-5 years and the Kurram Valley has lost its distinction as the only place in Pakistan where this quaint but potentially serious practice occurs. Discouraged by the decline in the take there, tribesmen enthusiastic about the sport have turned their sights on other places. Approximately 20 hunting parties now undertake the difficult drive to an area in the Zhob District in Baluchistan west of Zhob (formerly known as Fort Sandeman). An equal number head south along the Indus to Kashmore District on the border of Sind and the Punjab.

The Zhob group was by far the most successful in 1982. One party there is said to have caught more than 350 Demoiselle Cranes and a few others reportedly took in excess of 200. In contrast to their usual recent takes of around 1500 birds, hunting in Rojan (near Sind's border with the Punjab) was apparently frustrated last autumn when several parties were arrested, fined, and turned away by Punjabi officials. The camps along the Kurram Valley claimed only about 300-350 birds (compared to 600-750 in earlier years), virtually all Common Cranes.

In each case, the hunters fare about four times better in the spring, presumably because the breeding season is at hand and the birds are more inclined to descent along their way. In the autumn, the cranes will alight in dry areas away from the river banks, making it more difficult to predict their passage.

What is the fate of the birds once captured?

Because they are less aggressive and more elegant than Common Crane, Demoiselles are much less likely to be eaten. While 50 percent of the larger, more aggressive Common Cranes end up over a camp fire, only about 20-30 percent of the Demoiselles meet a similar fate. The cranes that survive are usually kept by the captors themselves, given to unsuccessful hunting friends or those who were unable to leave their responsibilities for such a long period. A few are entrusted to the care of men with a reputation for successfully breeding cranes in captivity.

Their territorial nature makes the cranes excellent watchdogs. As a result, it has become both fashionable and practical for wealthy families and hotels in cities like Peshawar to purchase one or more pairs of Demoiselle Cranes. Prices for individual birds start at Rs. 200 (US$20) and increase depending on the type, sex, size, appearance, and general condition.

Once captured, cranes are pinioned and eventually returned to the villages. There they are kept in very small round, topless reed cages of approximately 3x4 feet. They are desensitized to human and vehicular presence by being placed near a well traveled road. The birds are fed regularly and well by their captors with a diet that may include millet, sorghum, wheat, barley, and/or corn. After approximately 3-4 weeks, they will settle down sufficiently to be allowed outside of the owner's compound to range about at will.

Preliminary information gathered from hunters, local wildlife officials and direct observation indicates that villages around Bannu and nearby Lakki have as many as 600 cranes. Several sources estimate that the captive crane population in Pakistan exceeds 3000 birds. We have urged the NWFP Wildlife Department to carry out a detailed census to ascertain more accurately the number of captive cranes and to determine whether any Siberian Cranes are in captivity.

CAPTIVE BREEDING

A few of the wild-caught cranes have bred in captivity. After several years, males and females will form pair bonds. In a few cases, pairs will engage in nest building and breeding activities after 8-10 years in captivity. Nests, quite substantial in size, are built of straw and grasses in the corner of the owner's compound furthest from humans, animals, and other sources of disturbance. Egg laying takes place in late May or early June, somewhat later than might be expected in wild birds. One owner reported building a canopy sacking over the nest site to shelter the brooding birds from the sun (shade temperatures in the summer in Bannu can reach 45° C).

As in the wild, both captive parents share incubation duties. Once laid, the two eggs are aggressively defended by the parents. No animal — including dogs, domestic hens, or the owner himself — is free from attack when venturing within 15 feet of the nest. Sometimes under unusual circumstances the owner will find it necessary to move the eggs. One owner told us that the female would allow him to move the eggs with a shovel in her presence. If he moved them without her viewing the process, she would abandon them.

The chicks hatch after 30 days incubation and are carefully guarded by the parents. After about 3 days, they are accompanied out of the compound to forage in nearby fields. At this point some owners will catch mole crickets and grasshoppers and throw them in front of the parent cranes, who feed the insects to their chicks.

No Common Cranes were reported to be breeding in captivity. However, a pair of Demoiselle Cranes we observed has been producing chicks for five years; three young have survived. The same pair was successful in raising two chicks this year, in the wild a rare occurrence.

Some wild-caught cranes have lived 25 years in captivity. The oldest captive-born crane we encountered was a four year old nonbreeder from the pair mentioned before.

DISCUSSION

Crane hunting in Pakistan appears to have increased for the last twenty years. Considering the sacrifice the hunters must make to hunt the birds, the growth of the sport within the last four or five years is almost staggering. The implications of these developments for the few remaining Siberian Cranes are obvious.

Although the prospects of weaning the tribesmen from their sport are slim, it is important for the government and conservationists to develop educational programmes to make the people aware of the threatened status of the cranes. In light of the relative poverty of the people involved, perhaps some means can be found to provide economic incentives for the crane hunters to release or band and release birds they have caught — or to provide other recreational opportunities.

At present the Siberian Crane is partially protected by law in Pakistan. Hunting of the bird is prohibited in Sind and Baluchistan. Bag limits for Common Cranes and Demoiselle Cranes have been established in the Punjab. Cranes were included for a brief time on the NWFP's list of totally protected species in the mid-1970s. However, crane hunters mounted a strong and successful protest and the protection was quickly withdrawn.

The government of the NWFP imposes a small fee of 10 rupees for each crane kept in captivity. It is doubtful that much effort is made to collect such a nominal fee. A plan to increase the fee to 100 rupees may have two harmful effects: crane owners may kill their birds rather than pay the higher fee, or crane hunters may simply eat more of them in the field. To avoid these problems, the collection of a lesser fee could be used if crane owners participate in a systematic census of captive cranes.

The tribesmen are likely to be suspicious of conservation efforts. Educational and research programmes designed to increase the productivity of captive cranes would probably help gain their trust. Perhaps local owners with particular success with captive breeding could be hired to share their techniques with others. While increased captive breeding might not take much pressure off the wild populations, such a programme would at least increase awareness of the problems facing these birds.

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ALTERNATE WINTERING GROUNDS FOR SIBERIAN CRANES

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ABSTRACT

The paper describes briefly the interesting history of the shooting preserve at Bharatpur, later declared a sanctuary and then a national park. It sums up the reportof a survey of the wetlands in Uttar Pradesh, undertaken to ascertain where else the Siberian Cranes (western race) could go other than Bharatpur. At least two wetlands have been discovered where these birds were observed in the past. Suggestions for intergrated scientific management of a number of wetlands in Rajasthan, Uttar Pradesh, Madhya Pradesh and Haryana, are made.

The Keoladeo National Park at Bharatpur, Rajasthan, India, is spread over 29sq km. Of this, about 15sq km is wetland. It receives water from the Ajan Dam. More than a dozen villages are located along the periphery of the Park on three sides, while the city of Bharatpur flanks it on the fourth side. The Park has more than 350 species of birds, of which 140 species are winter residents. The rest of the species are passage migrants and permanent residents. Three species of cranes occur: the Sarus Crane (*Grus antigone*), the Siberian Crane (*G. leucogeranus*), and the Common Crane (*G. grus*). The Sarus Crane is a resident bird and breeds within the Park. The other two are winter migrants.

HISTORY

The natural depression, popularly known as Keoladeo Ghana, has an interesting history. Principal credit for its development should go to three persons: Lord Curzon; Harbhamji, the prince of Morvi; and Kishan Singh, the versatile Maharaja of Bharatpur. In 1899, Kishan Singh was an infant when the then Maharaja, Ram Singh died. Lord Curzon appointed Harbhamji as the Administrator of Bharatpur State, thus paving the way for the Viceroy's frequent visits here for duck shoots. The records instituted at the Keoladeo temple in the heart of this Park, indicate that Lord Curzon was the first person to organize shoots here. The present Maharaja, Col Sawai Brijendra Singh of Bharatpur, also contributed towards developing this wetland into a sanctuary after the country became independent.

The old records further reveal that at the beginning of the 20th century as many as 22 forest guards were posted here to look after the preserve. There were Game Laws enacted by the then State Council, which specified, "The holder of a license to keep guns is strictly forbidden to shoot in the jungles and the State Preserves; no cultivator is allowed to use a gun of which the barrel is more than 24 inches in length."

Interestingly, there are 22 forest guards looking after the National Park today. The difference, however, is that they are headed by a Deputy Chief Wildlife Warden. A few subordinate staff are added to this strength. The total management is based largely on man-material basis. The traditional method of management continues in relation to the discharge of water from the Ajan Dam, maintaining different levels of water in the lakes. Bharatpur was declared a sanctuary in 1956 and upgraded to the status of a national park in 1982.

Thouth there are no scientific documents available about the population dynamics of the avifauna of Bharatpur, it has been generally observed that the numbers of migratory species has been on the decline. The presence of some of the migratory species is also erratic. One year, for example, Pintails (*Anas acuta*) are the commonest species, in another year, Coots (*Fulica atra*). In 1982-83, Greylag Geese (*Anser anser*) outnumbered other species. There are crystal clear indications that the chemistry of Bharatpur water is undergoing a gradual change.

CRANES ON THE DECLINE

Lesser numbers of all the three species of cranes are observed in the Park presently compared with the past. Observations for the Common and the Sarus Cranes are not precise, but the Siberian Cranes have been counted individually over the years. Their sharp decline is as follows:

Year	Number of Siberian Cranes
1970	76
1974	63
1975	61
1977	56
1983	36

The records show that the number of Siberian Cranes is reduced by more than half at Bharatpur in course of the past 12 years. It indicates that their number may reach zero mark by 1995, if the present rate of decline was to continue.

These birds normally arrive here by the middle of November. Sometimes, they have been observed in late October. Their departure is generally early March. However, there is no set pattern for their arrival and departure. Once, for example, they landed in the Park as late as 12 January, and another time they left suddenly in the middle of February.

SURVEY OF OTHER WETLANDS

It is believed that the western race of the Siberian Crane winters only at Bharatpur in India. However, there are indications that these birds often go to other areas in the northern regions of India. To investigate their alternate winter grounds, an extensive survey was undertaken during 1982-83, a summary report of which is presented here.

The survey encompassed areas in the districts of Hardoi, Unnao, Kanpur and Itawa in the State of Uttar Pradesh. The following wetlands, or jheels, were visited.

1. Chamaria Jheel	2. Bahosi Jheel	3. Indergarh Jheel
4. Lakha Jheel	5. Bidhuna Jheel	6. Yakubpur Jheel
7. Rasulpur Jheel	8. Kadli Jheel	9. Gilthar Jheel
10. Narva Jheel	11. Kakwan Jheel	12. Samsi Jheel
13. Renas Jheel	14. Soni Station Jheel	15. Madikher Jheel
16. Darogakher Jheel	17. Bichhia Jheel	

Another dozen such wetlands which possessed no name were also visited. More than 50 bird species typical of wetlands were observed at these sites.

These wetlands have profuse vegetation of hydrophytes described as follows in the form of four life forms:

Free Floating — these occur throughout the water body and their position is governed by wind movement. The plants found are:

(a) *Eichhornia crassipes* (b) *Pistia stratiotes*
(c) *Lemna Minor* (d) *Spiroduela polyrhiza*
(e) *Azolla pinnata*

Rooted Floating — these are in relatively shallow areas:

(a) *Ipomea aquatica* (b) *Ipomea rubens*
(c) *Enhydra fluctuans* (d) *Eclipta prostata*
(e) *Jussiea repans* (f) *Nymphea* sp.
(g) *Euryala ferox*

Submerged — these are found in deep areas:

(a) *Potamogeton crispus* (b) *Hydrilla verticillata*
(c) *Ceratophyllum demersum* (d) *Vallisneria spirallis*
(e) *Najas graminea*

Emergent — these occur along the periphery:

(a) *Cyperus* sp. (b) *Cyperus rotundus*
(c) *Hygroryza* sp. (d) *Oryzasativa*
(e) *Scirpas articuloyus* (f) *Scirpas littorates*
(g) *Paspalidium geminatum*

A number of macro-invertebrates belonging to major groups as *Annelids, Gastropodes, Odonata, Ephemeroptera, Diptera, Hemiptera, Coleoptera,* and other groups also occur in these wetlands. Insects usually dominate the macro-invertebrate community throughout the year.

The wetlands of Uttar Pradesh are extensive enough to lure Siberian Cranes. Reports from these areas reveal that in January-February 1980, 5 Siberian Cranes wintered at a small jheel of about 20ha, at a place about 100km from Kanpur towards Itawa. This is adjacent to a small town known as Kakwan. It was also reported that one of these Siberian Cranes was trapped by the professional trappers. The trappers said these birds had not appeared in their area in living memory.

During the same period of January-February 1980, as many as 6 Siberian Cranes were reported by trappers at another wetland called Bahosi Jheel, which is about 15km from a small town known as Bela in Itawa district. This wetland has been considered a traditional wintering ground for a large number of migratory species, including Siberian Cranes.

During 1979-80, Bharatpur Sanctuary faced a severe drought following scanty rainfall in the catchment area of the Ajan Dam. Of the normal 15sq km wetland here, only about 3-4sq km area received water, and even that was utilized or dried up by the end of January. The State Forest Department took emergency steps to dig artesian wells to replenish the water in some of the lakes within the Sanctuary so that the migratory birds did not starve. The Sanctuary received a very small number of migratory birds that season. The Siberian Cranes were generally observed in smaller groups, and were frequently seen flying out of the Sanctuary, generally north and south. There is every possibility that these birds were in the wetlands of Uttar Pradash where they had been reported by Baker (1928), Sharpe (1894), Blyth and Tegetmeier (1881) and others.

It is obvious that the Siberian Cranes do at times go to wetlands other than that of

Bharatpur. It is possible that one section of the western race migratory flock visits Bharatpur and another goes elsewhere, thus leaving ornithologists guessing about their decline at Bharatpur.

The wetlands of Uttar Pradesh continue to receive a large number of water birds. This contrasts with their decrease at Bharatpur. While the lakes of Uttar Pradesh are not managed and protected at all, Bharatpur receives a fair attention by the government. There are other similar wetlands in adjoining areas falling in the States of Madhya Pradesh, bordering the Dholpur and the Chambal river bed, and in Haryana. These areas in Haryana, Madhya Pradesh and Uttar Pradesh deserve more investigation.

RECOMMENDATIONS

A check list should be prepared of all the wetlands available in the states of Uttar Pradesh, Madhya Pradesh, Haryana, and Rajasthan, within a 400km circle with Bharatpur at the center. A task force of bird lovers from government and nongovernment sectors should be constituted to study the population dynamics of migratory water birds in these areas.

Detailed hydrological observations should be recorded with specific regard to water inflow, water outflow, retention capacity, loss through evapotranspiration, manipulation of water level, load of silt and its impact on vegetation, afforestation programmes, etc.

Polution levels should be monitored with a special emphasis on phosphorous and nitrogen cycling, one of the chief factors responsible for degradation of water quality in wetlands.

Water levels should be managed to assure that wetlands are suitable for waterfowl.

A pilot management scheme should be chalked out for some of these wetlands for consideration as Closed Areas under the Wildlife (Protection) Act, 1972. Some of them may be exclusively kept for waterfowl and other species, with interference by local people and cattle prohibited.

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DISTURBANCE FACTORS AFFECTING SIBERIAN CRANES AT KEOLADEO NATIONAL PARK, INDIA

RONALD T. SAUEY

ABSTRACT

Observations made on Siberian Cranes (*Grus leucogeranus*) at Keoladeo National Park near Bharatpur, India during the winter of 1976-1977 showed that their daily activities were frequently disturbed by a variety of factors. Of the 5 commonest sources of disturbance, humans were the most important, accounting for 42% of the disturbance incidents and 46% of the cranes' total response time to all disturbances. Among humans, local people were responsible for a substantially greater amount of disturbance than were tourists. Conspecifics were the next most frequent source of disturbance incidents, causing 25% of all observed disturbances. These incidents were typically of short duration and amounted to only 15% of total response time. Sarus Cranes (*G. antigone*), on the other hand, were responsible for 14% of the disturbance incidents but 21% of the combined response time. In addition, 37% of Sarus Crane disturbances caused Siberian Cranes to temporarily abandon their daily territories, the highest percentage for any disturbance type. Domestic animals and wildlife were the other two sources of disturbance but were of minor importance. Response differences to disturbance among age and sex categories of Siberian Cranes, and the difference in frequency of disturbances for various parts of the sanctuary, were also analyzed. A brief discussion of the current conservation problems of this critically endangered bird is given, as well as a series of management recommendations.

INTRODUCTION

Keoladeo National Park located near Bharatpur, Rajasthan, in northcentral India is the sole place in India, and one of only three places in the world, known to harbor wintering Siberian Cranes (*Grus leucogeranus*). Each winter between mid-November and early March, small groups of these cranes feed and roost within Keoladeo's extensive wetlands, seldom leaving the park's boundaries during their four month stay (Sauey 1976, Spitzer 1979). The earliest record of Siberian Cranes at Keoladeo dates from 1937 when Dr. Salim Ali and Col. Richard Meinertzhagen shot one during a visit to the sanctuary, then the private hunting reserve of the Maharajah of Bharatpur (Salim Ali, pers. comm.). It is conceivable, however, that this species' use of Keoladeo may extend back to the middle of the last century when the sanctuary's wetlands, locally called *jheels*, were largely created by the Bharatpur ruler and his state engineers (Drake-Brockman 1905). Today, Keoladeo National Park is under the jurisdiction of the Forestry Department of the Government of Rajasthan, which continues to maintain the area's wetlands through a system of bunds (dikes), canals, reservoirs, and pumps, though the yearly water levels are still essentially dependent on the success of the July-August monsoon (Breeden and Wright, unpubl. ms.).

Keoladeo National Park is situated in one of the most heavily populated regions of India (*Fig. 1*). It is relatively small for Indian parks (approximately 2900 hectares) and is encircled by seven villages. The city of Bharatpur with a population of over 50,000 people (1971 estimate) is only 5km from the sanctuary. Agra (pop. 591,917) and Jaipur (pop. 615,258) are within a two hour's drive. Until recently, a tarmacked thoroughfare for local traffic passed directly through the sanctuary (*Fig. 2*) and for most of the daylight hours, and often well into the night, this road was in constant use by bullock carts, automobiles, scooters, and tour buses. Smaller collateral roads, actually the tops of bunds, branch off from the main artery and were also used, though less extensively, by pedestrians, domestic animals, and motorized vehicles. These roads divide the sanctuary into various sized jheels, some only a few hectares in size, others totalling a hundred hectares or more. All wetlands, however, are within easy viewing distance from roads and bunds.

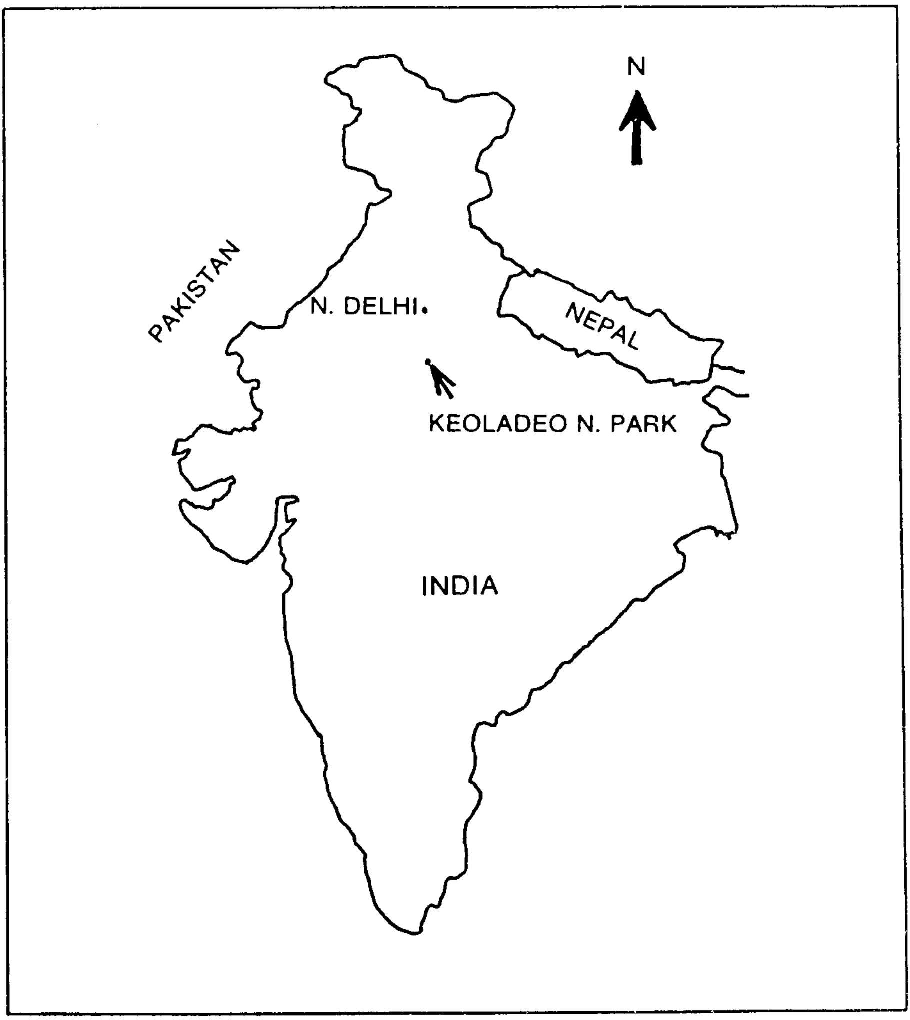

Fig. 1. Location of Keoladeo National Park.

The park's close proximity to villages and large urban areas and its network of easily accessible roads and bunds result in almost constant human activity within the sanctuary's borders. This human pressure, combined with several nonhuman factors, is often the source of disturbance for the Sanctuary's Siberian Cranes, as well as for other wildlife. During the winter of 1976-77, I spent four months at Keoladeo National Park (then called the Keoladeo Ghana Sanctuary) studying the behavior and ecology of this crane. During that time, I recorded many instances when this species was disturbed during its daily activities. In this paper, I review and analyze the types, frequency, duration, and result of such disturbances, and discuss their importance to the conservation of the Siberian Crane. I also include a set of recommendations that might reduce the frequency of such disturbances.

STUDY SITE AND METHODS

The study was conducted between mid-November 1976 and the first week of March 1977. Keoladeo's small size and its network of roads and bunds permitted nearly continuous and unobstructed observation of Siberian Cranes during daylight hours. That winter I recorded data on 21 of the 57 individuals present at the sanctuary. With the exception of 1 unpaired individual, each observed crane was part of either a pair or family unit. These included 3 pairs, each consisting of an adult male and female, and 4 families, 3 of which consisted of an adult male and female and a juvenile of unknown sex that was hatched in the last breeding season and was distinguishable by its brown and white plumage. An additional family consisted of an adult male (whose sex I determined by its size and aggressive behavior toward other cranes) and a juvenile. No female was ever seen to accompany this family; the original mate was presumed lost sometime prior to the cranes' arrival at the sanctuary.

Fig. 2 shows the four main areas where I recorded data on the cranes' daily activities. Site A was the most densely populated, with 11 of the 21 birds observed there. This area had standing water of varying depth interspersed with numerous man-made mounds of earth upon which the Rajasthan Forestry Department had planted Babul trees (*Acacia nilotica*). Cranes fed primarily in the deeper water (30-80cm), but often rested during parts of the day by standing or sitting on the mounds. Site B was the main feeding area for 1 pair. This part of the sanctuary had standing water also, but lacked the mounds and Babul trees. Site C, a territory for 1 family, was the most restricted from the public, due to a canal and the heavy planting of trees along this structure. It consisted primarily of standing water bordered with wet sedge meadow through which ran a long, tree-covered bund. Site D harbored 2 families, 1 of which was the family without a female. This latter family spent the first 4 weeks of the winter at site A, but the remainder at site D. Site D was located at the eastern edge of the sanctuary, an area of open, standing water and within .5km of the village of Ghasola.

Data presented in this paper were collected as part of a larger study of the activity budgets and behavior of Siberian Cranes. To collect this information, I observed pairs and family groups for 2 to 3 hour periods using a 20-60x Bausch & Lomb telescope and a 7x35 Nikon binoculars. Observation periods were scheduled throughout the day, but at staggered intervals to allow time for rest and meals. These periods alternated daily so that data were obtained for all daylight hours. I divided each observation period into 5 minute intervals, during which I carefully watched each bird's activities. At the end of this interval, I summarized the preceeding activities and their duration on prepared data forms. I took extensive notes in addition to the 5 minute summaries whenever I saw disturbance incidents or other unusual behavior.

For the purposes of this paper, I defined a *disturbance incident* as any interruption in crane activity that appeared to be caused by a stimulus or stimuli extralimital to such birds and eliciting curiosity, aggression and/or avoidance behavior. (Not considered in this analysis were disturbances that originated from intrapair or intrafamily interactions.)

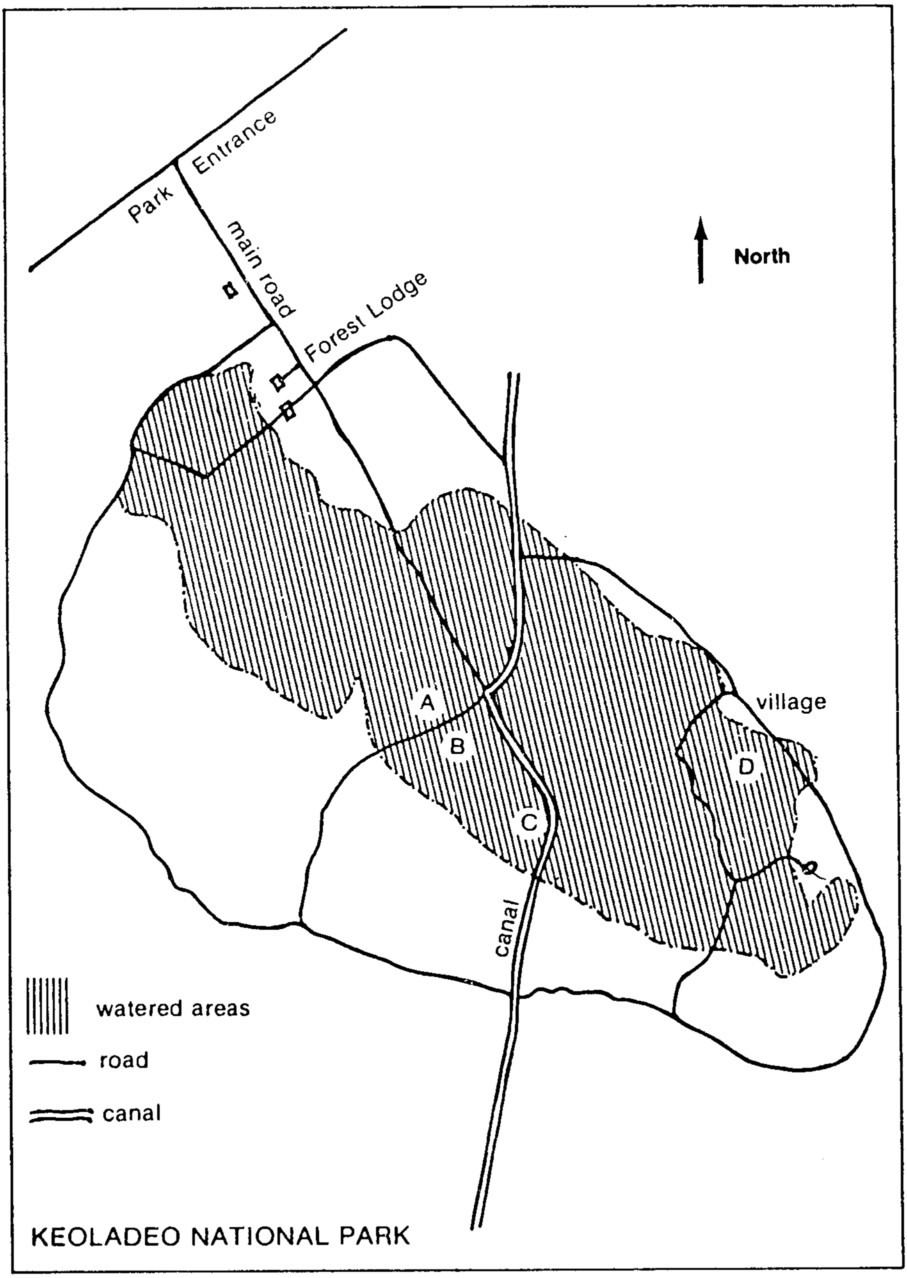

Fig. 2. Keoladeo National Park (formerly the Keoladeo Ghana Sanctuary). Figure shows the 4 main observation sites, A-D, used during the study.

For each disturbance incident, I recorded the apparent source of the disturbance and the response duration, i.e. the amount of time the birds appeared disturbed. Occasionally, the source of a disturbance was impossible to determine. In these cases, I recorded the source as unknown. Although most response durations were short and easily measured, there were disturbances that persisted over longer periods; cranes often acclimated to such disturbances and resumed normal activities, though remaining watchful and nervous. The response duration in these cases became difficult to measure and I could only estimate its length roughly.

In addition to the above observations, I noted all incidents that resulted in flight of the birds from the feeding area, judging these types of disturbances to be most detrimental to cranes. I did not, however, record the length of time the birds remained away from their territories since disturbed cranes often left for long periods and occassionally would not return until the next day.

RESULTS

Behavioral responses to disturbances

Depending on their nature and source, disturbance incidents evoked a variety of responses from Siberian Cranes. The weakest observable response was a brief glance by a bird in the direction of the disturbance source followed by continuation of its previous activity. More serious disturbances caused intense staring and cessation of activity. Basically, three types of responses were then possible: curiosity, aggression, or fear. Conflict behavior, normally involving encounters between Siberian and Sarus Cranes (*Grus antigone*), might be considered a fourth type of disturbance response, though it probably involved a mixture of aggression and fear (Manning 1969).

Curiosity was usually directed at objects in the near vicinity and caused a perceptable tensing in posture, with the individual either remaining stationary or moving slightly toward the disturbance source. Feathers were often sleeked, the neck stretched forward, and the head turned sideways with one eye directed at the cause. Juveniles appeared more curious than adults, and more frequently adopted this posture.

Aggression was most often directed at either conspecifics or Sarus Cranes and was evidenced by an upright, rigid stance with wings slightly elevated, exposing the thighs and increasing the apparent size of the bird. The head and beak were drawn downward against the neck, and the crane walked toward the disturbance source with a high-stepping, exaggerated gait. Such display-walking was interspersed with various other stereotyped displays involving wing-ruffling, bowing, growling, and water-swishing (Sauey 1976). Aggressive responses to animals other than cranes were directed most often at ducks, geese, and other waterfowl. Siberian Cranes occasionally chased these birds off tree mounds that were used communally by many species of birds as midday roosts. These incidents were of short duration and cranes showed little or no stereotyped behavior.

Fear and avoidance behavior were the most common response of Siberian Cranes to disturbances. In these situations, an individual adopted an upright, alert stance, its eyes directed at the disturbance source. A musical, high-pitched, and trilling "purr" was a common vocalization at such times and was repeated at one to several minute intervals depending on the source and seriousness of the disturbance. The crane then normally walked away from the disturbance source, looking back occasionally to relocate the cause of its alarm. Other times, a crane began this avoidance behavior and then, perhaps sensing more imminent danger, took flight. Although this response was usually initiated by sudden and proximate disturbances, flight could also be caused by less immediate disturbances that interrupted the bird's normal activities for extended periods.

Conflict behavior often resulted from incidents involving Sarus Cranes. The responding individual showed both fear and aggression. A typical posture was a low, crouched attitude with the bird's head and neck withdrawn toward the body and the wings depressed slightly. The individual alternated between advance and retreat and often pulled up large beakfuls of vegetation in the process, probably a form of displacement feeding (Sauey 1976).

Types, frequency, and duration of disturbances

During a total of 309 hours and 50 minutes of observation, I recorded 293 disturbance incidents. Thirty three of these incidents, 11%, were of unknown cause, but the remaining 260 incidents could be categorized into 5 disturbance types: domestic animals, man, conspecifics (Siberian Cranes other than intrafamily or intrapair members), Sarus Cranes, and wildlife (nondomestic animals other than cranes).

Domestic animals.

As many as 10,000 domestic animals grazed daily in the sanctuary during the winter of 1976-77 (Breeden & Wright pers. comm.). These were principally domestic water buffalo (*Bubalus bubalus*), Indian cattle or Zebus, and domestic pigs. Buffalo and cattle were brought into the sanctuary every morning by herders from the villages surrounding the sanctuary, and these animals spent most of the day moving from area to area within the sanctuary. The movement of cattle on the bunds and along the periphery of jheels seldom disturbed cranes, since these birds normally remained within the areas of deeper water. Water buffalo, however, spent the majority of their day within the jheels eating dense growths of aquatic vegetation and occasionally passing through crane feeding territories. Upon the approach of buffaloes, cranes stopped their activities and gave "purr" calls, but they seldom flew out of the area unless the buffaloes ran toward them or were accompanied by villagers. Domestic pigs also disturbed cranes if they entered the jheels, but they seldom walked more than a meter into the water, and the birds acclimated quickly to their presence. Domestic pigs were present only at site D near the village of Ghasola (*Fig. 2*), though wild and feral pigs were widespread and common in the sanctuary. Since these latter animals fed primarily at night, they were not a source of disturbance to cranes on their feeding territories.

Water buffalo and pigs accounted for about 2.5% of the disturbance incidents and about 4% of the total response duration recorded throughout the winter (*Fig. 3*) I recorded one incident of cranes flying from their territory because of domestic animal disturbance (*Fig. 4*).

Man.

During daylight hours, there was a constant and extensive human presence in the sanctuary. Most human activity was confined to the main road, which passed almost directly through the sanctuary (*Fig. 2*), but both foot and vehicular traffic occurred wherever roads were present. Such traffic brought people into close proximity to several crane feeding territories.

I differentiated between two types of human disturbance, local and tourist, since these two groups had different reasons for utilizing the sanctuary and behaved differently. Locals, including villagers and sanctuary game rangers, usually used the bunds and roads as thoroughfares to pass through the sanctuary, and seldom paused along the way. Locals also occasionally entered the jheels to gather aquatic vegetation or to herd buffaloes. Tourists, on the other hand, often and repeatedly stopped on the roads to view wildlife and sometimes used cars, buses, and other vehicles to travel throughout the park. They were also more likely to have radios and recorders and to travel in large, noisy groups.

Man, including both locals and tourists, accounted for 42% of the disturbance incidents and 46% of the winter's combined response durations (*Fig. 3*). Locals caused approximately 59% of human disturbances and tourists 35% (*Fig. 5*). Twenty two percent of the disturbances caused by locals and 18% caused by tourists resulted in cranes flying out of their feeding territories (*Fig. 4*).

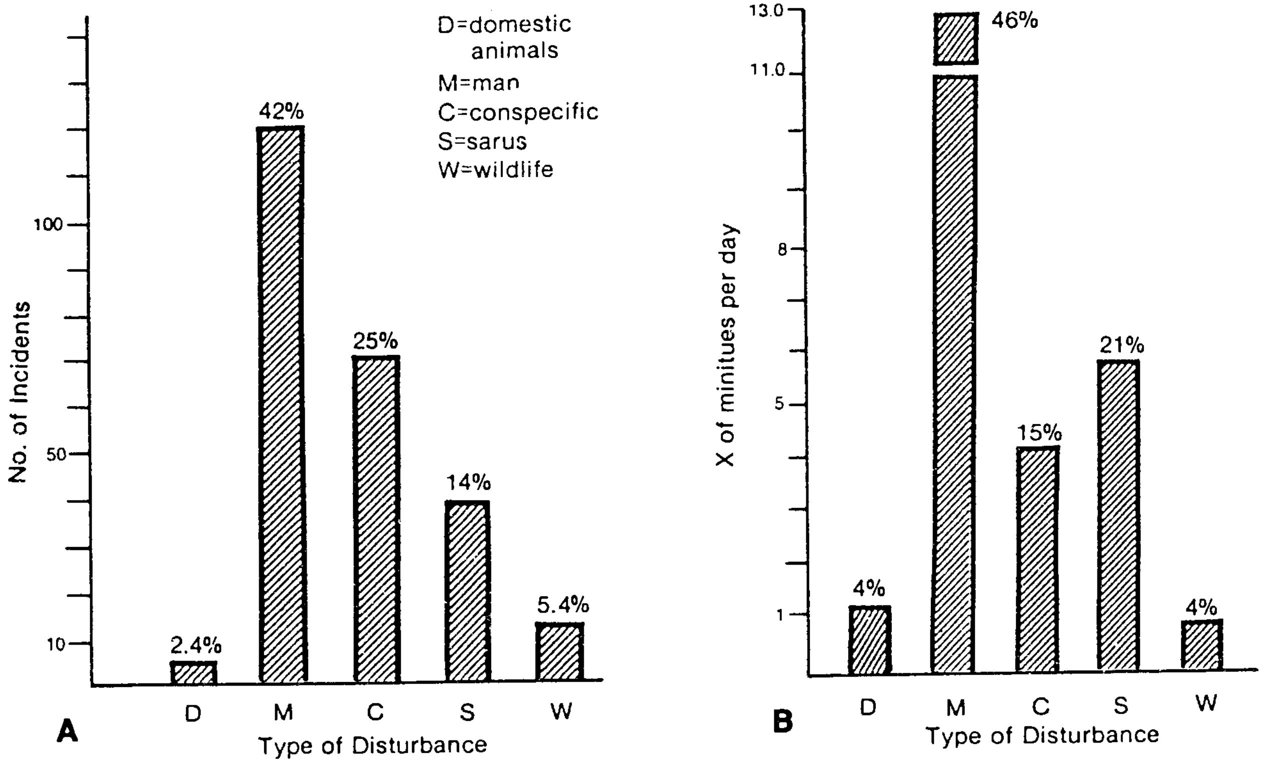

Fig. 3. Frequency of and Daily Response Durations to 5 Categories of Disturbances. Graph A shows the number of incidents caused by 5 sources of disturbance throughout the winter. Percentages are based on total number of disturbances, including those of unknown cause (approx. 11%). Graph B shows the mean number of minutes per day cranes were involved in disturbances caused by the same 5 disturbance types. Percentages are based on total disturbance times, including disturbance times from unknown causes (approx. 10%).

Disturbance Type	no. of occurrences	% of occ.
DOMESTIC ANIMAL	1	14
TOURIST	8	18
LOCAL	16	22
CONSPECIFIC	5	7
SARUS	16	37
WILDLIFE	0	0

Fig. 4. Frequency of Flight Response to Disturbances. Chart shows the number of occurrences of flight as a response to 5 sources of disturbance. Percentages are based on total number of disturbances, including those of unknown cause.

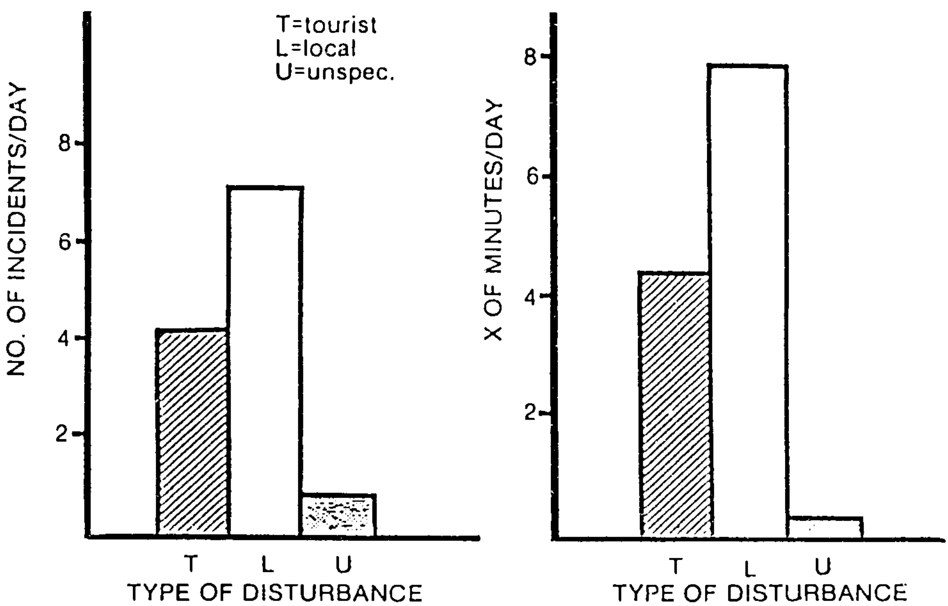

Fig. 5. Daily Frequency and Response Durations to 2 Types of Human Disturbances. Graphs compare the frequency and response durations on a daily basis to local- and tourist-caused disturbances.

Conspecifics.

Most Siberian Cranes maintained daily feeding territories at the sanctuary during the winter, though the majority roosted together at night. Such territories were used by pairs or families, and other cranes were excluded by various displays, both visual and vocal. Interactions between pairs or families occurred frequently, usually because other types of disturbances displaced birds from their territories and brought neighboring pairs or families into close proximity. At other times, the male of a family or pair intentionally flew into the territory of neighboring birds, causing aggressive interactions with the residents.

Conspecific interactions accounted for 25% of the disturbance incidents but only 15% of the combined response durations (*Fig. 3*). Seven percent of the disturbances caused cranes to leave their feeding territories (*Fig. 4*).

Sarus Cranes.

A natural antipathy seemed to exist between Sarus and Siberian Cranes at the sanctuary, and fights between these two species occurred frequently throughout the winter. The majority of these exchanges were initiated when a pair of Sarus Cranes either walked or flew into the feeding territory of a pair or family of Siberians. Such intrusions often caused the Siberians to fly out of their territories, particularly when Sarus Cranes themselves flew into the area uttering a loud and gutteral call. When Sarus approached on foot, Siberians either walked away from the advancing birds or remained at the site. In the latter case, the male Siberian usually began a series of advances and retreats, often repeatedly pulling up vegetation. On rare occasions, an actual fight ensued with sparring individuals of both species jumping up and lashing at the opponent with their feet. Most of these incidents ended quickly with either the Sarus or Siberians withdrawing. When Siberians left, Sarus Cranes often gave a unison call (Archibald 1974) much in the manner of the "triumph call" of the Greylag Goose (Lorenz 1978). Siberian Cranes, on the other hand, rarely responded with unison calls when Sarus departed from their feeding territories.

Sarus Cranes accounted for 14% of the disturbance incidents during the winter and 21% of the combined response durations (*Fig. 3*). Thirty seven percent of these incidents resulted in a flight response from the Siberians (*Fig. 4*).

Wildlife.

Species of wildlife other than cranes occasionally elicited curiosity, aggression, or fear from Siberian Cranes. The majority of these disturbances involved the two large species of mammals that often waded through the sanctuary's jheels, the Nilgai or Blue Bull (*Boselaphus tragocamelus*) and the Sambar (*Cervus unicolor*). Cranes usually paid little attention to these animals unless the latter waded near them. On these occasions, cranes gave "purr" calls and moved away. Eagles and other large birds of prey periodically flew over cranes but elicited little or no response except when raptors made passes at waterfowl near the cranes. This usually resulted in an "explosion" of ducks, coots, and geese from the jheel and general pandemonium for several minutes. Even at these times, cranes watched but seldom seemed frightened. I saw one aggressive interaction between a crane and a Spotted Eagle (*Aquila clanga*). The eagle swooped on a flock of waterfowl and in the process flew very close over the head of a crane. The crane quickly ducked and then jabbed at the eagle with its beak.

Wildlife-related disturbances made up 5.4% of the total disturbance incidents and 4% of the combined response durations recorded for all disturbances (*Fig. 3*). There were no instances of cranes leaving their territories because of disturbances caused by wildlife.

Response differences between males, females, and juveniles

Fig. 6 compares the average response duration (measured in mean number of minutes per day) of 9 males, 7 females, and 5 juveniles to 5 categories of disturbances. Males and females seemed to show only minor differences in response duration to all categories except conspecific disturbances. In the latter case, males appeared to spend nearly twice as much time involved in disputes with other Siberian Cranes than did females. To test this hypothesis statistically, a two way analysis of variance (ANOVA) was applied to the response times of males and females within each pair or family unit. This test showed that the response times for males were significantly greater than for females only during conspecific disturbances ($P < .0008$).

Juveniles, on the other hand, showed obvious differences in their response times to 3 of the 5 disturbance categories when compared to their parents. Juveniles spent even less time involved in conspecific disturbances than did their female parent. In addition, juveniles differed from both parents in their reaction to humans and Sarus Cranes, showing a good deal less concern than their parents when either of these two types of disturbances occurred. A two way analysis of variance (ANOVA) comparing juveniles to both males and female parents showed that juveniles differed significantly from both parents in their response durations to conspecifics ($P \leq .005$, with female parent), man ($P \leq .05$, with female parent), and Sarus Cranes ($P \leq .05$, with female parent).

Disturbance differences between feeding territories

Fig. 7 shows the relative frequency of the 3 most common disturbance types within 7 feeding territories. With one exception, that of the Odd-voiced Family (OVF) in observation area A, human disturbance, i.e. tourist and locals combined, was the most common cause for disruption in daily activities of Siberian Cranes in all parts of the sanctuary, though not necessarily the most serious. Disturbances stemming from encounters with other cranes, both Sarus and Siberians, were the next most frequent types of disturbances within all areas. Conflicts with conspecifics were prevalent in areas A and C but of minor importance in areas B and D. Sarus Cranes, on the other hand, caused disturbances frequently in areas A, B, and, to a lesser extent, D, but were absent in C. Finally, wildlife such as deer, antelopes, and birds of prey were important disturbance factors only in the territories of OVF and The East Side Pair (ESP), in areas A and B respectively.

A summary showing the average number of disturbance incidents per day, their mean duration, and the percentage of day each of 7 pairs or family units were disturbed can be seen in *Fig. 8*. In terms of the percentage of day the family or pair was involved in disturbance incidents, the two most disturbed feeding territories appeared to be those of OVF in area A and the East Village Family (EVF) in area D. The least disturbed territories belonged to the Plantation Pair (PP) in area A and the Chuckwa-chuckwi Family in area C.

DISCUSSION

Man was clearly the most important cause of disturbance for Siberian Cranes during the winter of 1976-77. Of the 5 disturbance categories, man was responsible for both the highest number of disturbance incidents and the largest percentage of total response time from the birds. This was not surprising, given the large human population in the immediate vicinity of the sanctuary, the accessibility of the latter to all types of traffic, and the small sizes of the jheels the cranes used as feeding territories. What is noteworthy, however, is that locals, i.e. residents of the surrounding villages, had as serious a disruptive effect on the cranes as did tourists. During the study, I had been advised repeatedly by sanctuary game rangers and by visiting Indian ornithologists that birds in India seldom showed fear of people in local dress and that to avoid frightening cranes during my study I might consider dressing in the local "kaddhi," consisting primarily of dyotis or long kurta-pajama outfits. This claim is an old one; many 19th century British ornithologists like A.O. Hume and T.C. Jerdon told of the surprising tameness of Indian birds around native-dressed people. Yet I could not detect either subjectively or from the data a difference in the reaction of Siberian Cranes to native- or western-dressed people. The

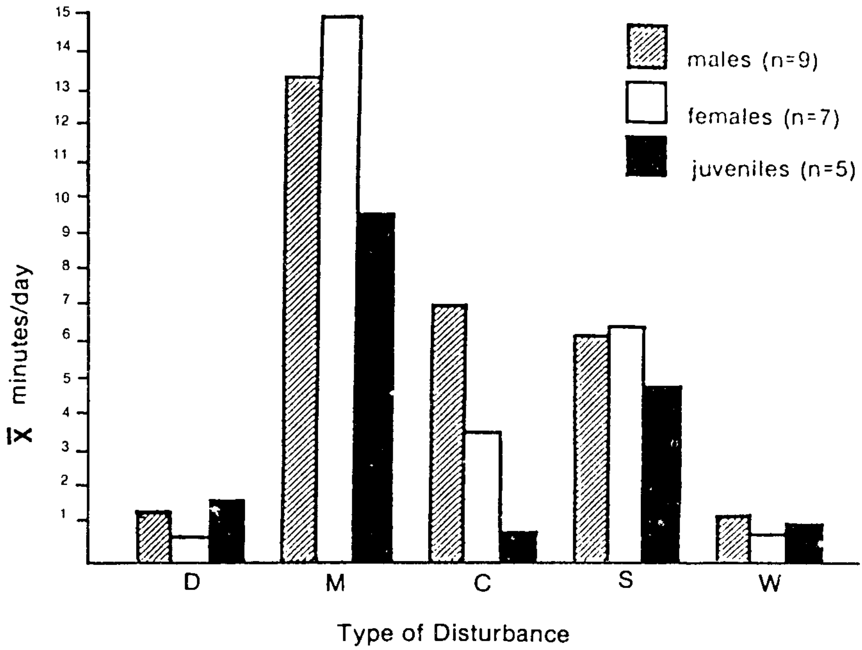

Fig. 6. Comparison of Response Durations of Males, Females, and Juveniles to 5 Categories of Disturbances. D=domestic animals, M=man, C=conspecifics, S=Sarus Cranes, W=wildlife other than cranes.

appearance of either on the bunds adjoining a feeding territory could lead to "purr"-calling and occasionally evasive behavior on the part of the birds. This was true even in area D, which was located close to the village of Ghasola on the eastern edge of the sanctuary and was rarely visited by tourists. This jheel, however, often attracted throngs of locals during the day who used this area for a variety of purposes. Neither of the two crane families that had feeding territories there became accustomed to the villagers' presence; they often flew out of portions of the jheel that were closest to human activity.

Another indication of the similarity of response to locals and tourists was the closely comparable percentages of flight reactions to the two types of human disturbances, 18% for tourist incidents and 22% for locals. The usual stimulus for flight, however, seemed to differ between tourists and locals. Locals most often caused cranes to take flight when they entered the water, usually with their livestock. Tourists, on the other hand, most often caused flight by stopping on the bunds to watch the cranes themselves, sometimes remaining for several minutes in full view of the nervous birds. Cranes in such situations seemed to fly more because of the lengthy interruption in their activities rather than because they were unduly frightened.

Only one feeding territory, that of the Odd-voiced Family in area A, did not have human activity as the major source of disturbance. That territory was located far back from an accessible roadway and tourists never approached close enough to disturb the family. Herdsmen with buffaloes also did not use this place, perhaps because of the dense emergent vegetation (mainly *Scirpus* sp.) near the jheel's edge. The Chuckwa-chuckwi Family in area C was also isolated from human disturbance because its territory was separated both from local and tourist traffic by a deep canal and a heavily planted bund. My own presence was the primary cause of human disturbance for this family.

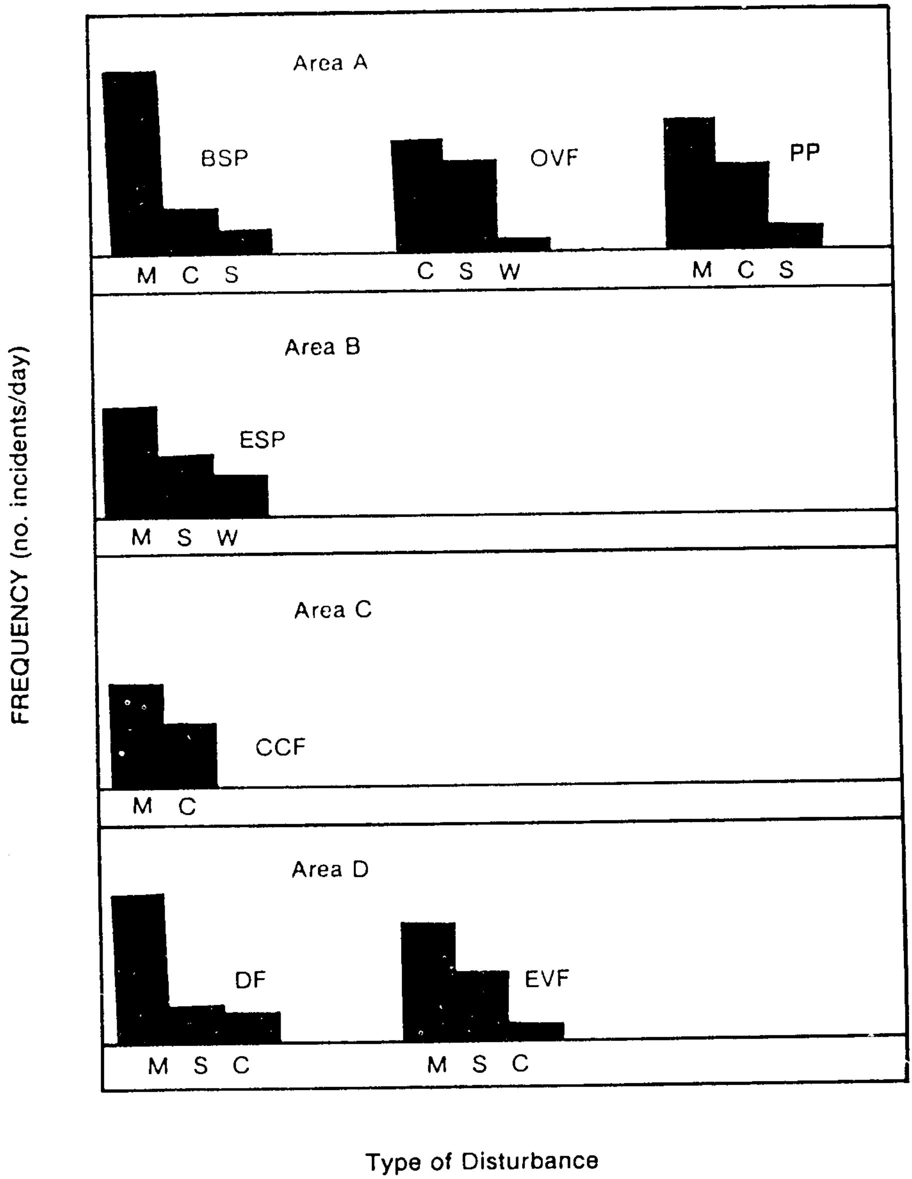

Fig. 7. Comparison of Major Disturbance Sources at 4 Observation Areas. Graph compares the relative amounts of time spent by 3 pairs and 4 families in the 3 most frequent types of disturbances at the 4 observation sites. M=Man, C=conspecifics, S=Sarus Cranes, W=wildlife other than cranes, BSP, PP, and ESP are pairs; OVF, CCF, DF and EVF are family groups.

Bird desig. (n)	AREA	Observ. (Time Hr/Min)	No. of Incidents	$\overline{X}$-Duration (Min)	Average No. Incid/Day	% of day
BROWN-STAIN PAIR (2)	A	21/45	25	2.2	13	4.1
DUO FAMILY (2)	D	66/55	66	2.7	11	4.3
CHUCKWA-CHUCKWI FAMILY (3)	C	18/05	6	2.3	3.8	1.4
EAST-SIDE PAIR (2)	B	36/25	27	2.6	8	3.0
EAST-VILLAGE FAMILY (3)	D	73/15	97	2.5	14	5.1
ODD-VOICED FAMILY (3)	A	28/00	25	3.6	10	5.2
PLANTATION PAIR (2)	A	50/20	38	1.8	9	2.3

Fig. 8. Summary of Disturbance Incidents for Pairs and Families. Figure gives mean response duration (to all types of disturbances) and percentage of day birds are involved in disturbance incidents for 3 pairs and 4 families.

Conspecific disturbances were the next most frequent type and the only kind in which males and females differed significantly in their response. In many cases, females paid little or no attention to territorial disputes involving their mates, and reacted strongly only to actual intrusions by neighboring males or pairs. Males, on the other hand, usually spent a certain portion of each day threatening neighbors, particularly in area A where there was a greater concentration of birds. Likewise, flight responses to conspecifics often involved only males, who occasionally flew from their territory to adjoining territories to quarrel with neighbors.

As stated earlier, conspecific disturbances occurred most often in area A, where 11 of the 21 cranes included in this study spent the day. In addition to these birds, there were several other pairs and a loose group of nonbreeding birds that fed in the general vicinity. The large number of cranes utilizing this area was the principal reason for the relatively high levels of conspecific interaction there (*Fig. 7*). In contrast, no other cranes shared area B with ESP and conspecific disturbances were consequently of minor importance.

The tendency for males to guard and defend their territories more actively than females has been noted in other crane species such as the Whooping Crane (*G. americana*) (Allen 1952, Blankenship 1976) and the Sandhill Crane (*G. canadensis*) (Walkinshaw 1965). This "watchdog" behavior may stem from greater aggressiveness (i.e. a lower threshold for aggressive behavior) in male cranes, a trait that has been documented in captive studies (Archibald 1974, Kepler 1976, Katz 1978). Male cranes are also generally larger and more robust than their mates, indicating that there may have been sexual selection for a greater male role in territorial defense.

While Sarus Crane disturbances occurred less frequently than those involving conspecifics, other parameters, such as the length of response time and the percentage of incidents resulting in flight, indicate that Sarus Cranes were a more important and serious source of disturbance at the sanctuary. The relationship between Sarus and Siberians was of great interest since at times they tolerated each other, but at others threatened and fought fiercely. At dusk, for example, both crane species roosted together peacefully in shallow water northwest of area A (*Fig. 2*). Shortly after dawn, Sarus Cranes flew out of the roost to feed in agricultural fields outside the sanctuary, while Siberians dispersed to specific daily territories within the park's borders. Yet in these feeding territories Siberian Cranes were often approached, threatened, and occasionally driven off by resident pairs of Sarus Cranes.

These reactions at first seem contradictory, but they in fact indicate that Sarus and Siberian cranes treated each other like conspecifics. Though both species tolerated each other at roost, I suspect that the Sarus which joined the Siberians nightly were nonbreeders or pairs without territories. They consequently reacted benignly to their white cousins, treating them as simply other roost mates. Likewise, Siberians off their territories at the communal roost had no quarrel with Sarus Cranes. During the day, however, both Siberians and Sarus were prone to defending their territories, a daily feeding territory in the former case, and a breeding territory in the latter. Where these areas overlapped or were too closely adjacent, the two species came into conflict.

Sarus Cranes nest and maintain territories primarily on the edge of the sanctuary's jheels and seldom feed within the shallow lakes themselves (Spitzer 1979, Prakash Gole, unpubl. ms.). Siberian Cranes, conversely, fed almost exclusively within the jheels and rarely left the water except in area A, where certain individuals rested and preened on tree mounds. Thus the two species utilize slightly different niches, which probably diminishes the frequency of territorial disputes. Spitzer (1979) believed that the Siberian's preference for feeding in more open and deeper water may be a direct response to the presence of Sarus Cranes in the drier uplands and along jheel edges. Yet Siberians wintering at Fereydunkenar in Iran, well out of the range of the Sarus Crane, also spent the day feeding in open, shallow water rather than uplands or along the water's edge (Archibald, pers. comm.). The recent discovery of another large wintering population of Siberian Cranes near Poyang-hu in Jiangxi Province, China, may also shed some light on the species' preference for wintering habitat.

Sarus Cranes were a frequent source of disturbance in all daily territories except the Chuckwa-chuckwi Family's (CCF) territory in area C. This territory was in large open wetland and sedge meadow which was bordered on three sides by roads and on the fourth side by a long broken bund (*Fig. 2*). The nearest "edge" that winter was nearly ¼km east of the territory. The presence of a "screening" bund and the large distance to typical Sarus habitat along the jheel's edge may have secluded CCF from the attention of neighboring Sarus pairs.

In contrast, the territory of OVF was close to the edge of the wetland in area A and this family had the most frequent and severe disturbances from Sarus Cranes (*Fig. 7*).

Although only 14% of the recorded disturbance incidents were due to Sarus Cranes, 37% of these incidents resulted in Siberian Cranes leaving their territories, the highest percentage of any of the 5 disturbance categories. Sarus Cranes, therefore, were second only to man in their importance as a source of disturbance to wintering Siberian Cranes. Moreover, as I shall discuss later, Sarus Cranes may have a greater potential for increasing their detrimental effect on Siberians during drier winters.

Domestic animals and resident wildlife played relatively minor roles as disturbances to Siberian Cranes. Large mammals and birds of prey were the most frequent sources of disturbance, but such incidents were of only short duration and never caused cranes to vacate their territories.

CONSERVATION PROBLEMS — AN ANALYSIS

Fig. 9 shows the recent numerical history of the Siberian Crane at the Keoladeo National Park. Since 1970, the wintering population of these cranes in India has declined approximately 53%, from 76 individuals (Konig, pers. comm.) to 36 in the winter of 1982-83 (B. Khan, pers. comm.). At least 2 theories have been advanced to explain this decline: (1) Hunting pressure on migratory waterfowl including cranes in Pakistan and Afghanistan is too severe and is taking a yearly toll in the population which cannot be recouped at present recruitment rate (Sauey 1981, Landfried & Roberts, this volume). (2) Year to year variations or decline in habitat quality at Keoladeo results in insufficient food reserves for return migration (Sauey 1976, Spitzer 1979). A third explanation, the loss of viability due to excessive inbreeding within a small population, is also possible and has often been used to interpret the decline of other rare species including the Whooping Crane (Allen 1952). Because of the lack of information on the genetic history of Siberian Cranes, I will not discuss this latter possibility. It is noteworthy, however, that after a reduction to fewer than 21 individuals in the late 1930s, Whooping Crane numbers have increased nearly fourfold (Labud & Butts 1979).

Hunting and habitat pressures are not mutually exclusive, of course, and both conditions might be contributing to this species' decline. The question is compounded by the probable influence of stochastic events on a population of this small size (Slobodkin 1961). Still, analysis of *Fig. 9* might provide a few clues about the causes and control of mortality in these birds.

Despite the significant decline in the population over the last decade, the number of juveniles arriving in India each fall compares favorably with populations of cranes that are either stable or increasing (Drewien 1973, Erickson 1976). This probably indicates that conditions are relatively favorable for the species on its breeding grounds in western Siberia. Concerns expessed by some Soviet authors such as V.E. Flint and A.A. Kistchinski (1981) and I. Neufeldt (1974), that hunting and other kinds of human pressures in Siberia are an important limiting factor for the species, may be unwarranted for this particular population. In addition, though little is known of the summer range of nonbreeding Siberian Cranes, if the species follows a pattern similar to Whooping or Sandhill Cranes (Drewien 1973, Anderson et al. 1980, Kuyt 1981), the majority of birds of all age classes

WINTER	TOTAL NUMBER	NO. OF ADULTS	NO. OF JUVENILES	% JUVENILES	% CHANGE IN POPULAT'N	REFERENCE	COMMENTS
1936-37	11	--	--	--	--	Dr. Salim Ali, personal commun.	one adult shot and eaten
1964-65	200	--	--	--	--	Walkinshaw 1973	probably inaccurate, 2nd hand report
1967-68	100	85-	15	15	--	V. Saxena personal commun.	estimate ?
1968-69	120	--	--	--	+20	V. Saxena personal commun.	estimate ?
1969-70	76	--	--	--	-37	Konig, personal commun.	entire population ? Ab-i-Estada, Afghan.
1973-74	92	68	24	26	--	Bhisham Chandra, personal commun.	estimate ?
1974-75	63	57	6	10	-32	Sauey 1976	careful survey made several times
1975-76	61	54	7	11	-3	George Archibald, personal commun.	careful survey made several times
1976-77	57	50	7	12	-7	Sauey 1979	careful survey made several times
1977-78	55	47	8	15	-4	Paul Spitzer, personal commun.	juvenile count is presumed correct
1978-79	41-43	--	--	--	-25 to -22	S. & B. Breeden, personal commun.	exact number never determined
1979-80	33	30	3	9	-23 to -19	Bholu Khan, personal commun.	severe drought
1980-81	33	29	4	12	0	Bholu Khan, personal commun.	
1981-82	38	32	6	16	+15	Bholu Khan, personal commun.	
1982-83	36	30	6	17	-5	Bholu Khan, personal commun.	

Fig. 9. History of Siberian Cranes Numbers at Keoladeo National Park.

spend the summer on or near the breeding areas. One might assume then that the whole population experiences a similar "benign" summer environment.

If this reasoning is accurate, the high mortality seen in this population over the last decade is occurring either on migration or at the Keoladeo Park itself. My own impression is that cranes are relatively secure at Keoladeo, though an old or infirmed bird may sometimes die there of natural causes. During the winter of 1976-77, for example, I counted 57 cranes throughout the 4 months the birds were at the sanctuary. I never saw a single instance of attempted predation on the species nor any weak or obviously distressed individuals. After the cranes departed India in early March, I followed them to Ab-i-Estada in southeastern Afghanistan, one of the few migratory stopovers known for this population. At the lake, I could find only 56; one bird was either delayed or had died migrating to the lake.

Migration certainly seems to be a likely period for mortality in these birds. This population passes through 38 degrees of arc latitude between its breeding and wintering grounds, an immense area that encompasses vast deserts, mountains, plains, and forests, and undoubtedly is subject to sudden and adverse weather changes, particularly in spring. As Spitzer (1979) points out, a bird that is malnourished or in otherwise poor health after a winter with inadequate food supplies will not likely survive the ordeal. Sauey (1979) provided evidence that juvenile Siberian Cranes gradually weaned themselves from dependance on parents for food during the winter, but showed little improvement in finding food for themselves. This age group might be particularly susceptible to perishing on the return trip to Siberia.

Yet the last decade's two driest and presumably most stressful winters, those of 1974-75 and 1979-80, are not reflected in a marked decline in the numbers of cranes arriving in the succeeding winter. In the 1974-75 winter, the sanctuary had some rain, but by January most of the shallow wetlands were dry and the majority of the 61 cranes were forced to feed together in a deep jheel (Mansarover) southeast of the temple (*Fig. 2*) (Sauey 1976). This contrasts with a normal winter, when birds have feeding territories scattered throughout the sanctuary. The next winter, 9 individuals were missing from the previous year's flock, a tragic decline, but about average for the decade. The winter of 1979-80 was even drier after a failed monsoon, and only puddles of water were available for the birds. Conditions were so adverse that Siberian Cranes did not regularly use the sanctuary, and flocks of cranes would appear and disappear for varying lengths of time. Usually a mere 12 individuals were seen, but one day a group of 33 was present. Cranes using the sanctuary that winter were almost continuously disturbed by people and domestic animals vying for the rapidly dwindling water supplies (Breeden & Wright unpubl. ms.). Despite these adversities, only 4 of the 33 individuals seen that winter failed to return the next year, one of the lowest declines in recent history. Although I'm assuming that the 33 birds seen for 1 day constituted the entire population, the fact that 33 cranes again turned up the next year is still surprising given the apparent severity of the preceding winter.

If conditions at Keoladeo National Park can also be discounted as the primary factor in the decline of the Siberian Crane, the remaining possibility, that the birds are experiencing their principal losses on migration, perhaps through hunting, gains additional support. That hunting pressure exists on this population is undeniable; a French ornithologist actually chanced upon several Siberian Crane specimens in a Kabul bird market in the late 1960s (Puget 1969). There is also evidence that the hunting of Common (*G. grus*) and Demoiselle (*Anthropoides virgo*) Cranes is widespread in both Pakistan and Afghanistan (Nogge 1978, Roberts 1977), and increasing in the former country (Landfried & Roberts, this volume). Such hunting undoubtedly endangers Siberian Cranes as well, especially since this species may occasionally join its more common cousins on migration (Sludsky 1959). Moreover, there is an historical precedent for a small population of cranes to be adversly affected by hunting. Robert Porter Allen in his 1952 monograph on the Whooping Crane considered hunting to be a primary culprit in the decline of that species during the early 20th Century. Since that time, the enactment of stringent hunting laws and the widespread dissemination of public information on Whooping Cranes have doubtlessly contributed to the species' slow recovery.

RECOMMENDATIONS

However one interprets the data on Siberian Crane numbers in India, the fact remains that this tiny population cannot long survive an 8.6% net decline per year. It is vital that every effort is made to protect this bird throughout its enormous range. In India this task seems relatively straight-forward: protect and enhance suitable Siberian Crane environment at Keoladeo National Park. What is more difficult is deciding what is suitable environment and what steps are necessary to protect and enhance it. I know from personal experience that the wrong conclusions can be drawn from inadequate data. My first winter (1974-75) at Keoladeo was one with lower than average water levels and after January the majority of cranes fed en masse in one of the deeper jheels. Based on my observations that winter, I decided that the tree planting policy of the Rajasthan Forestry Department was detrimental to Siberian Cranes since these birds never utilized those wetlands that were planted with acacia trees (Sauey 1976). Two winters later when there was an adequate water supply, I found that many cranes actually seemed to prefer planted jheels, perhaps because trees act as natural territorial boundaries or screens. The fact that they failed to use these jheels in the dry winter was due more to insufficient water depth than because of the presence of trees.

Consequently, I offer the following management reccommendations with the proviso that our knowledge of Siberian Crane ecology and behavior is still incomplete. Our approaches may have to change as more is learned about these birds.

1. Man has the greatest disruptive effect on Siberian Cranes at the sanctuary. Without strict control over human access to the park, it is inevitable that the area will lose its function as a sanctuary, and its cranes as well. In November 1982, the Rajasthan Forestry Department completely closed the park to grazing, a step which was politically risky and resulted in a serious riot. At last hearing, the matter was under review by the legislative body of the Government of Rajasthan. Although the Forestry Department's action and its aftermath were unfortunate to the locals who depended on the area to graze their cattle, it was clear to me and to other naturalists who know Keoladeo well that prior to the 1982 closing the Forestry Department had lost control over the locals' use of the sanctuary. For example, although the Forestry Department yearly issued only 2,000 grazing permits, more than 10,000 cattle were being brought into the sanctuary in the late 1970s. Walls erected by the Forestry Department to regulate the entry of cattle and domestic buffalo were quickly torn down by villagers. Unauthorized cutting of firewood and collecting of aquatic vegetation were done openly and with only token opposition from the authorities. Without some kind of drastic action, these problems could well have permanently undermined the integrity of the sanctuary.

Given this history and the potential for ever greater demands on the sanctuary by the locals, it is recommended that the current ban on grazing be continued. If studies currently contemplated by the Bombay Natural History Society determine that limited grazing is not detrimental or is even beneficial to the sanctuary then grazing should be reauthorized — but only if strict control is possible and is rigorously enforced.

2. A different kind of human use, tourism, is likely to increase in the future as the beauty and attraction of the park gain more public awareness. Park managers must remain vigilant to the potentially disruptive effects of too many tourists within this small park. Although Siberian Cranes acclimate well to human presence, noisy or unruly groups of people will always be a source of disturbance to these birds.

All visitors to Keoladeo should be given a small brochure written in both Hindi and English explaining proper behavior in wildlife sanctuaries. No loud talking, singing, or boisterous behavior should be allowed upon penalty of expulsion from the park. Radios and other noisy devices should not be played. The brochure should be positive in tone, explaining the importance of the park and its birds and mammals. The same information might be made into a signboard at Shanti Kutir, the Government of Rajasthan's resthouse.

All motorized vehicular traffic should be restricted to the main road and no vehicles should be allowed on bunds, including sanctuary vehicles, except under emergency conditions. Wildlife photographers should not be permitted to build blinds in jheels without permission of the Deputy Chief Wildlife Warden. Photographers using blinds or hides should be monitored by sanctuary staff to ensure that Siberian Cranes are not being disturbed. Boats should be restricted from any jheel that harbors Siberian Cranes.

3. Sarus Cranes, though a natural element of the sanctuary, often prove a serious cause of disturbance for Siberian Cranes. This enmity is undoubtedly not a recent development, but it may be exaccerbated by the small size of Keoladeo's jheels. As I have pointed out, the Sarus Crane is mainly an "edge" species, preferring to maintain nesting territories in the shallower parts of jheels, and feeding both on land and water. Siberian Cranes, on the other hand, seem to favor the deeper and more open areas of jheels. The frequent altercations between these two species at Keoladeo may be a function of the small size of the sanctuary's jheels, which bring Siberian Cranes close enough to Sarus nesting territories to provoke aggressive behavior.

Although little can be done to change the physical dimensions of the sanctuary itself, it is vitally important that adequate water levels be maintained in the jheels throughout the winter. The less water, the smaller the jheels and the more chance for harrassment of Siberian Cranes by Sarus, as well as other types of disturbances. Due to the 1979-80 drought, several tube wells were dug in the sanctuary to augment the natural water supplies (Breeden & Wright, unpubl. ms.). It is vitally important that these wells be maintained in good order and that they be used in times of drought to provide suitable habitat for cranes and other species dependent on the sanctuary in winter.

In India, I am grateful to Mr. Bholu Khan and other staff at the Keoladeo National Park for making my frequent visits there always informative and hospitable. I also thank Belinda Wright and Stan Breeden for their continual assistance and encouragement both in and out of India. In the U.S., I am particularly indebted to Barbara and Joseph Brownsmith whose computer and statistical talents were indispensible in completing this paper. Finally, I thank Dave Ferguson and the U.S. Fish & Wildlife Service's Office of International Affairs for providing funding for travel to and from India.

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SIBERIAN CRANES WINTERING IN THE LOWER YANGTZE IN CHINA

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ABSTRACT

After 2 years of searching, in 1980 Siberian Cranes (*Grus leucogeranus*) were discovered in China, wintering on the lower reaches of the Yangtze River. Approximately 100 birds were found at Boyang Lake in Jiangxi Province. In 1981, some 230 Siberian Cranes were found in several flocks that later converged on Boyang Lake. Their habitat, behaviour, and ecology are described.

According to past records, Siberian Cranes (*Grus leucogeranus*) wintered in the lower reaches of the Yangtze River (La Touche 1933), but the localities were not given in detail.

In the winters of 1978, 1979 and 1980, we searched for Siberian Cranes in Hubei, Jiangxi, Anhui, and Jiangsu Provinces along the middle and lower reaches of the Yangtze River. We first found flocks of Siberian Cranes in the winter of 1980 at Dahuchi (115° 57′E, 29° 08′N), about 9km northeast from Yongxiu County in the western part of Boyang Lake in Jiangxi Province. About 100 cranes were seen.

The water covered area at Boyang Lake is about 3000km^2 in size during the wet period from April to September, while during the dry period from October to March, the area is reduced to about 500km^2. A large part of the lake bottom becomes exposed, with many sandy, muddy and weedy banks, forming a peculiar natural environment, described by the saying — "Water touching sky in summer and fall, muddy bank with no ending in winter and spring."

In winter and spring, the depth of water in Boyang Lake at Dahuchi is about 20cm. In 1981 and 1982, the authors made a detailed investigation in the area of Boyang Lake. In addition to field surveys, several aerial surveys, each of 1-3 hours, were carried out.

In the winter of 1981, 91 (9 juvenile) Siberian Cranes were found wintering at Dahuchi. Another, smaller flock of about 50 was seen in Sanshan, about 30km east of Dahuchi. The total number of Siberian Cranes wintering in China was, therefore, about 140.

In 1982, several aerial surveys found Siberian Cranes only at the west side of Boyang Lake. However, it is not limited to the area of Dahuchi. Before December, there were only a few Siberian Cranes in Dahuchi. There were another two big flocks, one of about 100 found in Xiaotanhu, 20km away southeastward from Dahuchi, and another of about 100 found in Dashafan, 30km further southeastward. On 6 January 1983, these two groups converged on Dahuchi, with a total number of 230, among which 19 were juvenile. This is quite different from the conditions we found in 1981. According to our analysis, the reasons are: (1) The water retreated late in 1982, so the water level of the lake was high, and the area of shallow water of Dahuchi was small. For this reason, Siberian Cranes gathered on some larger areas of shallow water before December. In January, when the water level dropped, the cranes flew back to Dahuchi again. (2) In January, the temperature decreased, due to strong winds, and there was snow on 9-10 January. However, along the eastern bank of Dahuchi, a hill of about 30m which served to block the wind. (3) There was more food in Dahuchi than in other places. Based on our investigations in recent years, there is no better place in the middle and lower parts of Yangtze River than the western part of Boyang Lake for wintering Siberian Cranes.

The 230 Siberian Cranes wintering at the western side of Boyang Lake are probably migrants from the Yakutia area of the Soviet Union, passing through northeast China to Boyang Lake. This assumption, however, remains to be confirmed by further investigations. Generally speaking, Siberian Cranes arrive at Boyang Lake in the middle or end of October and leave to migrate north at the end of February and the beginning of March.

Wintering Siberian Cranes are gregarious. Sometimes one flock was divided into several small groups, of 40-50 or 10-20 birds. Sometimes, a group consisted of members of only a single family (two adults and one juvenile).

Siberian White Cranes while flying were arranged in "V" or "I" forms. When flying, they gave short and weak calls of a high frequency.

The wintering cranes ranged in an area at Dahuchi around Zhonghuchi, Banghu, and Dachahu about 12-15km in diameter. They were generally found in widely open marsh, with plenty of aquatic plants, and free of disturbances. According to our survey, Siberian White Cranes feed on roots and buds of aquatic plants such *Vellesnerui sperals*.

Besides Siberian White Cranes, about 400-500 White-naped Cranes (*Grus vipio*) and about 150 Hooded Cranes (*G. monachus*) were found wintering at Dahuchi. These three species of cranes lived together in harmony, but their feeding and resting places were each different. Siberian Cranes were found on the shallow water areas, while White-naped Cranes were on the muddy banks near the shallow water area. Sometimes a few Siberian Cranes and White-naped Cranes were seen in mixed flocks. Hooded Cranes were generally found in muddy and weedy areas far from the shallow water areas. The crane flocks actively fed from the time of sunrise to about 1000 hrs. and about 1400 to about 1730 hrs. Siberian Cranes fed in the water continuously for several minutes at one time. They were timid and alert, and took flight immediately as soon as there were any disturbances.

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THE SIBERIAN CRANE: ITS HISTORY AND BIOLOGY IN CAPTIVITY

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ABSTRACT

The Siberian Crane (*Grus leucogeranus*) has a long history in captivity, but did not breed successfully in captivity until 1981. As of 1983, the total captive population stands at about 39 birds in 8 institutions. The methods used for maintaining and breeding these birds at the International Crane Foundation are outlined. Semen production by males for artificial insemination is examined and compared with egg fertility. It appears that females require frequent multiple inseminations of high quality semen during the ten days preceding egg laying. This is complicated by captive males often showing erratic semen production.Patterns in egg laying and changes in egg characteristics were examined as to what effects double clutching might have had on one individual female. For this bird, the interval between successive eggs increased throughout a given laying period, during which the eggs became successively less heavy and rounder. Yearly mean egg weight increased with the female's age; mean elongation and the mean interval between eggs did not change. No deleterious effects due to double clutching could be identified for the years in question. Females will lay up to 11 eggs per year in captivity. The mean incubation period for 6 eggs was found to be 29 days. A growth rate equation is given for the critical period of days 4-30. In comparison to other crane species, Siberian Cranes seem to take longer in reaching maturity. Siberian Cranes are generally long lived in captivity. Areas requiring additional work in the captive management of these cranes are discussed.

INTRODUCTION

The Siberian Crane (*Grus leucogeranus*) is a migratory resident of Asia rapidly approaching extinction in the western part of its range. This crane once bred across the tundra and taiga of northern Asia and wintered from Iran to China.

Today, approximately 1500 wild Siberian Cranes exist in two disjunct populations. A western population of about 50 birds breeds in western Siberia near the Ob River and winters in Iran and India. The eastern population of about 1450 breeds in eastern Siberia (Yakutia, U.S.S.R.) and winters at Poyang Lake in China. The disjunction has probably arisen in historical times owing to extirpation by man of connecting populations.

In response to the sharp declines in wild populations, captive breeding programmes for the Siberian Crane were initiated at the International Crane Foundation (ICF) in Baraboo, Wisconsin in 1976 and later at the Oka State Nature Reserve in the U.S.S.R. These were meant to provide protected reserve populations and to produce eggs for reintroduction attempts. This paper will provide an historical account of Siberian Cranes in captivity, the present distribution of those in captivity, and will examine the biology of this species in captivity at ICF.

HISTORY IN CAPTIVITY

Siberian Cranes have long been kept in captivity. Astley (1900) reports, without comment, having kept these cranes. Jean Delacour (pers. comm.) stated that they were readily procured from animal dealers during the early part of this century. They were not favoured avicultural subjects, however, because of their propensity to eat ducklings, and were considered unattractive because of their bare red faces (Tavistock & Delacour 1931). The largest documented number of captive Siberian Cranes, prior to 1976 when ICF first conceived its propagation programme, was in 1962 when apparently 17 birds were held in 11 institutions (Jarvis & Morris 1963). By 1976, only eight birds remained in six collections on three continents (Olney 1977). Despite its long history in captivity, the Siberian Crane did not breed successfully in captivity until 1981 at ICF.

During the 1960s, a pair of Siberian Cranes at the St. Louis Zoological Park was given a separate enclosure when signs of breeding were apparent. They nested and hatched one chick, which died before fledging (W. Conway, pers. comm.).

Several erroneous reports of Siberian Cranes breeding in captivity exist in the literature. In 1962, the Ueno Zoo in Tokyo reported raising one Siberian Crane and in that same year the zoo in Colombo, Ceylon, reported raising an unspecified number of these birds. However, neither zoo reported keeping Siberian Cranes in their collections (Jarvis & Morris 1963). Early volumes of the International Zoo Yearbook used 'Asiatic Crane' as the common name for *Grus leucogeranus*, which may have resulted in confusing it with the commonly kept Sarus Crane (*Grus antigone*) or perhaps other species. In 1964, a lone male Siberian Crane at Whipsnade Park, Great Britain, was reported to have been bred in captivity, yet in reports of previous and subsequent years there is no other reference to this status for this individual. Another lone bird in Paris was reported as captive-bred in 1966 and 1967, whereas again in all previous and subsequent years there is no reference to that status (Jarvis 1965-1968, Lucas 1969-1971, Lucas & Duplaix-Hall 1972, Duplaix-Hall 1973-1975, Olney 1976).

CURRENT STATUS IN CAPTIVITY

As of early 1983 there were about 39 Siberian Cranes in captivity at eight institutions. Thirty of these birds are believed to have originated from the eastern population, five from the western population, and four are the result of breeding an eastern female to western males.

The Soviet crane breeding center at Oka State Nature Reserve has two western and 12 eastern birds. One western bird was confiscated from a citizen who had received it as a chick and had raised it with dogs. The second western bird was collected as a hatching egg in 1981. One eastern bird was collected as a chick when it became separated from its parents. The 11 other eastern birds were obtained as hatching eggs in 1979 and 1980. An additional 10-12 eastern hatching eggs were taken to Oka in 1983. The Vogelpark Walsrode in West Germany has three eastern birds collected as hatching eggs in 1980. A single Siberian Crane, probably from the western population, is kept at the West Berlin Zoo (Olney 1981).

Eight Siberian Cranes, probably all from the eastern population, are reported from four Chinese zoos. The Beijing Zoological Park has three birds. How and when these birds were acquired is uncertain. A single bird of unknown origin is housed at Sian Zoological Park (C. Wang, pers. comm.). Four other birds were reportedly trapped by local people in 1983, of which three are now kept at Changchun Zoo and one at Dalian Zoo (D. McNeal, pers. comm.). An eastern bird recently kept at Tama Zoo, Tokyo, captured in 1980 as an immature errant migrant separated from its parents, died from a leg injury in November 1982 (M. Hisada, pers. comm.). Thirteen Siberian Cranes are currently kept at ICF. Seven of these birds are from the eastern population, and two probably from the western population. Four captive bred birds are the result of artificially inseminating an eastern female with semen from two western males. For a summary of the present distribution of captive Siberian Cranes and their probable sexes see *Table 1*.

Table 1. Distribution of captive Siberian Cranes in 1983.

Institution	Number of Birds			
	Eastern Population	Western Population	East x West	Total
Oka State Nature Reserve, U.S.S.R.	9/3/0a	1/1/0		14b
Vogelpark Walsrode, West Germany	2/1/0			3
West Berlin Zoo	-	1/0/0	-	1
Beijing Zoo	1/2/0	-	-	3
Changchun Zoo	0/0/3	-	-	3
Dalian Zoo	0/0/1	-	-	1
Sian Zoo	0/0/1	-	-	1
ICF	3/4/0	2/0/0	3/1/0	13
Totals	15/10/5 (30)	4/1/0 (5)	3/1/0 (4)	22/12/5 (39)

a. #/#/# designates number of males, females, and individuals of unknown sex respectively. Sexes of birds at ICF are accurately known. Sexes of birds at other institutions are best estimates.

b. Total does not include birds raised from hatching eggs collected in 1983.

SIBERIAN CRANES AT ICF

Between 1976 and 1979, ICF secured on breeding loan four birds: one from the Hirakawa Zoo, Kagoshima, Japan, one from the Philadelphia Zoo and two from the Vogelpark Walsrode, West Germany.

The Philadelphia female, named Philis, previously believed to be a male, and a male from Vogelpark Walsrode, named Wolf, arrived at ICF in July 1976. They were housed in adjacent pens until they appeared compatible and thereafter shared a common enclosure. Philis had been in captivity since 1952 without laying. In 1977 she laid ten eggs after being put on an artificial lighting schedule with increased daylength just prior to and during the breeding season. All of these eggs were infertile even though she had been regularly artificially inseminated with semen having low sperm concentration from Wolf. Later in 1977, a presumed male, named Hirakawa, arrived from Japan. This bird had been found in 1968, in poor condition as an immature on Okinawa Island, apparently after becoming separated from its parents during migration. This bird's small size and higher pitched voice suggested it might be a female. Hirakawa was placed in visual contact with Wolf and Philis in an adjoining pen. In February, 1978, Wolf attacked and killed Philis and then paced along the fence trying to attack Hirakawa. By the end of March, Hirakawa had laid the first of ten eggs. Wolf fertilized, via artificial insemination (AI), one of these eggs, but it failed to hatch. In 1979, all of Hirakawa's eggs were infertile although she consistently received low concentration semen from Wolf via AI.

Another male (Tilliman) was obtained from the Vogelpark Walsrode in the autumn of 1979. In 1980, four of Hirakawa's seven eggs were fertilized by Tilliman by means of AI. All embryos died during late stages of development while being artificially incubated. In 1981, Tilliman fertilized three of Hirakawa's ten eggs. This time the eggs were placed under surrogate parents for incubation. The embryo of one egg died at about two weeks of age. Another egg hatched; the birth of this chick (Dushenka) was widely reported in the popular press. The third fertilized egg also hatched but this chick died 12 hours after hatching. In 1982, four more Siberian Cranes, fathered by Wolf and Tilliman, were hatched; three were successfully reared.

Six additional birds were added to ICF's flock from hatching eggs collected in Siberia in 1977 and 1978. In 1977, the two eggs that were fertile out of four collected were hatched and reared. In 1978, two of seven eggs were infertile; the remaining five were hatched and four were reared. Hirakawa and these six subadults are from the eastern population. Wolf and Tilliman are thought to be from the western population and were probably trapped many years ago in India, which was a major supplier for the bird trade. All chicks reared in 1981 and 1982 resulted from breeding the eastern female, Hirakawa, with western males.

CAPTIVE MANAGEMENT

Methods and Materials

At ICF, chainlink enclosures, 20x20m, are subdivided to house 2-3 individual cranes. Inner subdivisions are constructed of 2.5 or 5cm poultry netting. The outer-perimeter fencing extends 2.7m above ground and is buried to a depth of 0.7m; electrified wires are strung around the top to prevent the entry of predators. In a corner of each enclosure is a 5x5x2.5m unheated wooden building on a concrete slab, where food and water are provided. The floors are covered with wood shavings to provide secure footing. These are kept about 15cm deep during the winter to provide insulation for the birds' feet. Each enclosure is covered with black nylon flight netting. Although the pens are covered, all primaries on one wing of each bird are clipped back to the coverts to prevent panicked individuals from flying into fences and being injured. Since the death of Philis, owing to the high levels of intraspecific aggression these birds exhibit, all adult and subadult Siberian Cranes are housed singly in each subdivision.

Beginning 1 February, breeding birds receive a pelleted breeder diet containing 20.5 percent protein with a calcium/phosphorous ratio of 2.45 percent: 0.89 percent. The birds are given this diet throughout the breeding season and until the post nuptial molt is completed. For the remainder of the year the birds receive a maintenance diet containing 19 percent protein with a 1.0 percent: 0.86 percent calcium/phosphorous ratio. Each bird receives a handful of whole corn (maize) daily during the winter months for additional carbohydrates. Fresh water is supplied daily in 15 liter buckets or automatic cattle waterers. Newly hatched chicks receive a starter diet containing 23 percent protein for about the first 14 days or until they show a steady weight gain. Thereafter, they receive the adult maintenance diet (LaRue 1980a, Russman & Putnam 1981).

Beginning 1 March, the birds' daylength is artificially extended to 16 hours with the use of automatically controlled floodlights in the birds' pens and shelters. The lights switch on during the night and off at sunrise such that the birds experience a natural sunset and an artificial dawn. This 16 hour light period is then extended each week by advancing the artificial sunrise by one hour until the birds receive a combined natural and artificial daylength of 23 hours seven weeks later. The 23 hour daylength is maintained until females stop laying eggs, sometime between late April and mid-May.

Due to high levels of intraspecific aggression, males and females are housed singly in adjoining pens, allowing only visual and vocal contact. Pairs will perform many aspects of courtship, but obviously cannot copulate. Semen collection from males and artificial insemination of reproductively active females is performed three times weekly. In addition, females are inseminated immediately after each oviposition. AI was also used with Wolf and Philis, who were housed together but failed to copulate. For details on semen collection and insemination procedures see Gee & Temple 1978, LaRue 1980b, and Putnam 1982. The quality of semen for AI is scored A=4, B=3, C=2, D=1, F=0 based on the concentration of spermatazoa as viewed through a 400x microscope. For a qualitative and graphical description of the standard, see Putnam (1982).

To encourage females to lay multiple clutches, eggs are collected within, at most, 15 hours after laying.

In 1978 and 1980, eggs were artificially incubated in forced air incubators. From 1981 on, eggs were typically placed under incubating pairs of Florida Sandhill Cranes (*Grus canadensis pratensis*). This race was chosen because it lays earlier and often breeds more reliably in captivity than do other Sandhill races. Several days before the expected hatching date, the eggs are removed from the surrogates and moved to a forced air incubator where the hatching process can be observed. Hatching eggs are monitored by placing the egg against one's ear and listening to the chick's activities at least four times daily until the eggshell is pipped.

The chicks hatched from eggs collected in Siberia and the chick reared in 1981 were handreared following the methods used for other crane chicks. Chicks are taught to eat by presenting food in a red spoon. During the first 2-3 weeks they are housed individually in 1.0x1.0x0.5m brooder boxes. Several times daily chicks of a comparable age are exercised outdoors on a grassy lawn. As the chicks grow, they are moved to larger individual pens (LaRue & Hoffman 1981).

In an attempt to raise birds not imprinted on people, the Siberian chicks hatched in 1982, as well as two Red-crowned Crane (*Grus japonenis*) chicks, were reared in isolation units. This procedure was first tried in 1981, using two Blue Crane (*Anthropoides paradisea*) chicks. The isolation units consisted of heated indoor areas with adjoining outdoor runs. Chicks were taught to eat using a puppet modeled after the head and neck of an adult conspecific. Chicks were not allowed to see people for the first several months, but were allowed to see their own images in a mirror, as well as the chicks in adjacent pens (Putnam 1982). In 1982, three Siberian Cranes were isolated from hatching onwards for one, two, and three months each, as were two Red-crowned Cranes for one and two months each.

Careful and exhaustive records are maintained on each parent bird, egg, and chick. The compilation and maintenance of written records is essential for operating a successful captive breeding programme (Sauey & Brownsmith 1977, Putnam 1982). These records provide a benchmark by which future problems in the birds' management may be evaluated. For example, it is possible to judge whether a chick's progress in hatching or later growth rate are sufficient. From these records, patterns in a bird's biology may be identified which allow aviculturalists to anticipate future events or needs.

Results

Siberian Cranes are quite similar to most other crane species in the various aspects of their courtship behaviour, such as unison calling, dancing, and precopulatory calling. One behaviour seen in Siberian Cranes, and not in most other crane species, is painting, in which adults of either sex actively apply mud to their feathers. Whereas Sandhill Cranes will paint all the feathers they can reach with their beaks, Siberian Cranes paint only both sides of the base of the neck and nearby body feathers. Painting in Siberian Cranes precedes semen production and egg laying and is a useful indication of the birds' coming into breeding condition.

Semen Production

Semen samples of A or B (highest) quality are most desired for AI as samples of lower quality appear to have insufficient concentration of spermatazoa for fertilization. Earliest and latest dates for obtaining A or B samples from Wolf are respectively 27 February 1980, and 30 May 1981; for Tilliman, 1 March 1980, and 22 May 1982. The mean yearly production period for A or B semen for Wolf (1977-1982) is 44.2+17.3 days (x+sd; range 17-57 days). The mean production period of A or B semen for Tilliman is 57.0+21.8 days (1980=72 days, 1981=32 days, 1982=67 days). Yearly grade-point averages of semen quality from Wolf have improved erratically from 1977 to 1982 (1977=1.0, 1978=1.75, 1979=1.78, 1980=1.54, 1981=1.17, 1982=2.5). Conversely, yearly averages of semen quality from Tilliman have tended to decline (1980=2.88, 1981=1.0, 1982=1.57). *Fig. 1* reveals that semen production is rarely consistent throughout a given year and that production of A or B samples does not always correspond closely with the female's laying cycle.

Comparison of semen production and egg laying schedules (such as in *Fig. 1*) allows each egg to be allocated to one of four different insemination classes (*Table 2*). Egg fertility was 82.4% when the female was inseminated with A or B semen two or more times within ten days of oviposition *and* when at least one of these inseminations came no more than five days before oviposition. Two eggs in which two or more A or B inseminations came 6-10 days before oviposition were both infertile. Eight in which only one A or B insemination came 2-10 days before oviposition were all infertile. Inseminations occurring less than 48 hours before oviposition were not included in this analysis since crane eggs appear to spend more than 24 hours, and perhaps up to 48 hours, in the oviduct during their formation (Putnam, unpublished data). Philis laid no fertile eggs in 1977, her only year of production. Mean fertility for Hirakawa for years 1978-1982 was 31.1% (14/45) ranging from 0% in 1979 to 86% in 1982.

Table 2. Egg fertility in relation to insemination schedule.

Frequency of inseminations with A or B quality semen	# Fertile	# Infertile	% Fertile
Once, within 2-5 days of oviposition	0	5	0
Once, within 6-10 days of oviposition	0	3	0
Two or more, with at least one within 2-5 days of oviposition	14	3	82.4
Two or more, within 6-10 days of oviposition	0	2	0

Egg Production

In 1977 Philis laid her first egg on 26 March. First laying dates for Hirakawa, from 1978-1982, ranged from 22 March 1980, to 14 April 1982. The duration of the egg laying period for Hirakawa for years 1978-1982 was 42.4±9.8 days ($\bar{x}$±sd, range 33-55 days). In 1977, Philis laid 10 eggs; Hirakawa has laid from 7 to 11 eggs, with a yearly mean of 9±1.9 ($\bar{x}$±sd, years 1978-1982). An analysis of covariance reveals no statistically significant relationship between the date of the onset of egg laying and the number of eggs laid in a year ($t=1.055$; $0.40 > p > 0.30$; df=4) (*Fig. 2*).

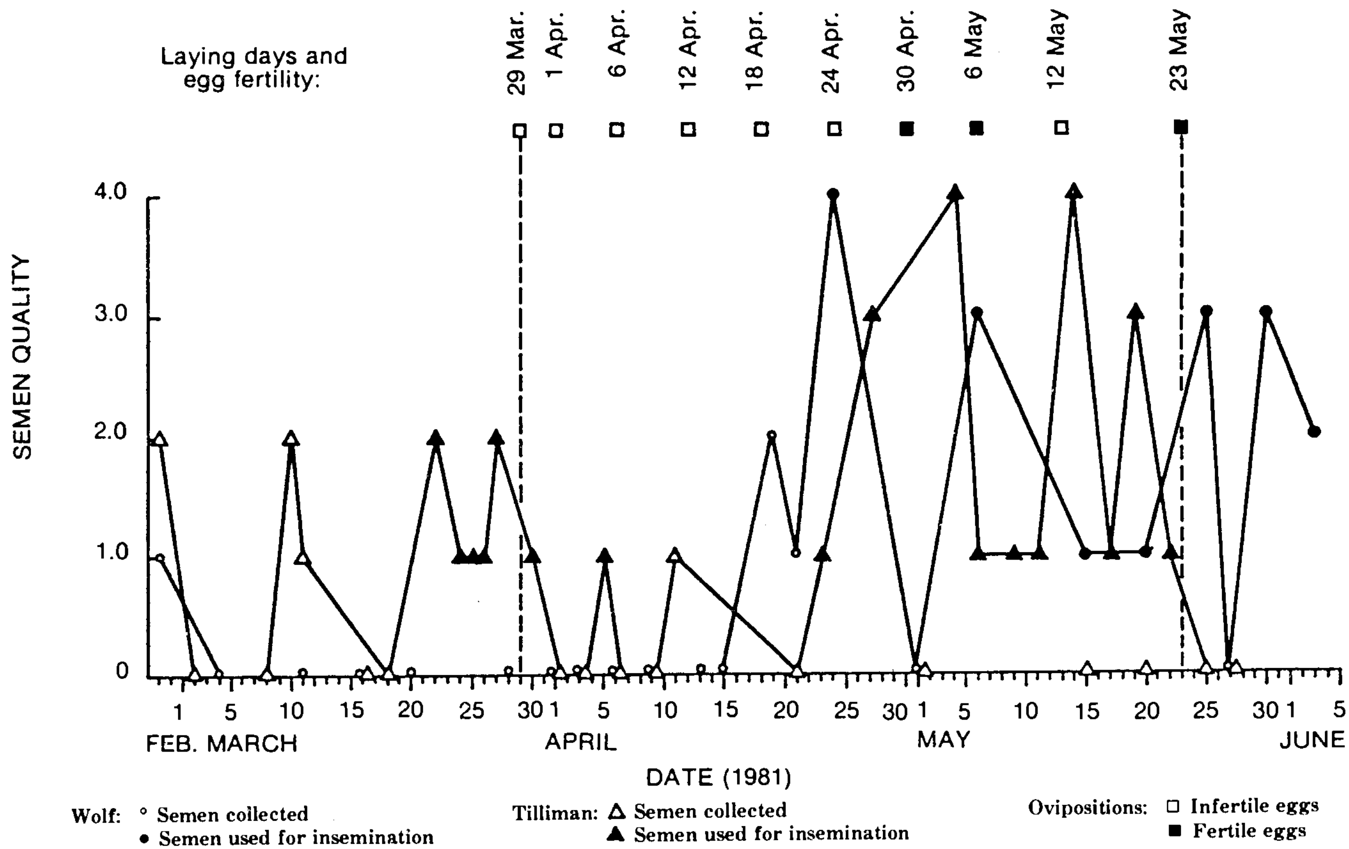

Fig. 1. 1981 semen production by Wolf and Tilliman and the fertility of eggs laid by Hirakawa.

In the one year (1979) for which we have a spring weight for Hirakawa (6800g), mean egg-weight represented 3.12±0.20 percent of her body weight ($\bar{x}$±sd; 2.70-3.45 percent; n=11). The total number of eggs laid represents 34.3 percent of her body weight, 5x the weight of the first two eggs, which would constitute a normal clutch representing about 6-7 percent of her body weight.

The removal of early clutches of eggs to induce females to continue egg laying, or double-clutching, is a common practice with certain types of birds in aviculture. Double-clutching has also recently been applied to certain endangered wild birds, such as the California Condor (*Gymnogyps californianus*), in an effort to boost the productivity of declining populations. Little information exists as to what consequences may arise from this practice. To examine what effects double-clutching might have on captive cranes, changes in the interval between successive eggs, changes in egg weight, and changes in egg shape,

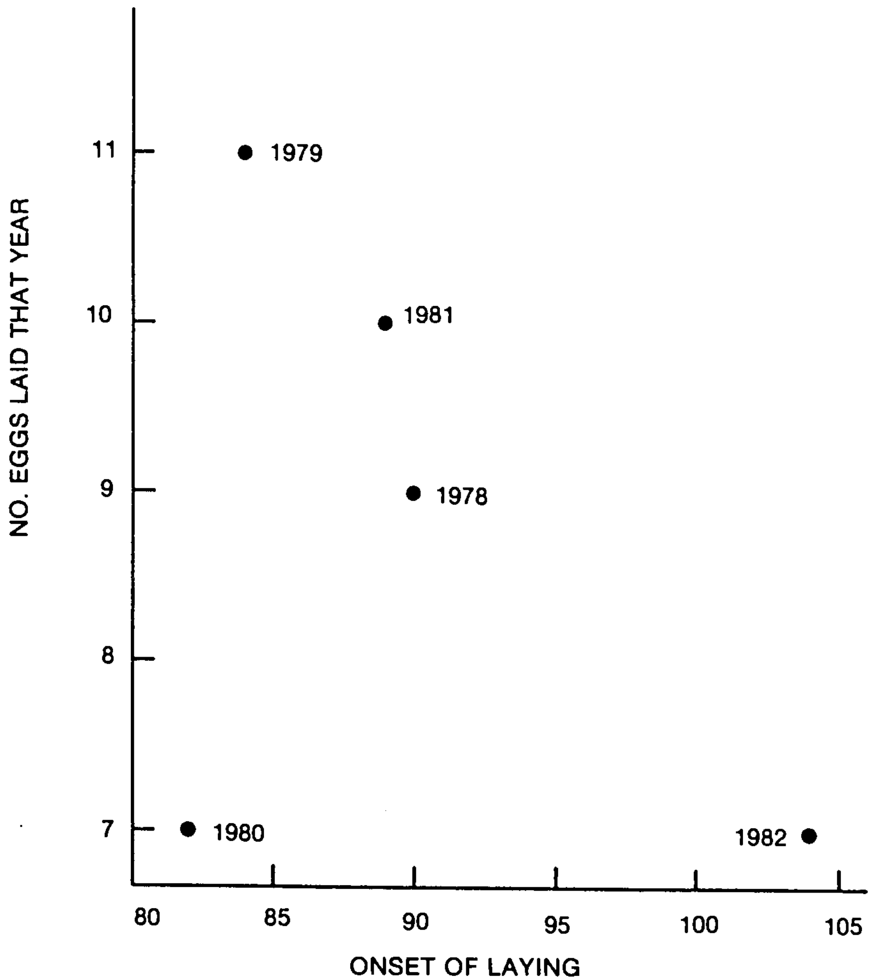

Fig. 2. A comparison of when the first egg of a year is laid and the total number of eggs laid in that year. No statistically significant relationship, t=1.055; 0.40 > p > 0.30; df=3.

both within a yearly laying period and among years, have been analyzed using Hirakawa's egg laying records from the years 1978-1982. Analyses of covariance have been used in all cases to examine trends in these data.

The interval between successive eggs increased significantly throughout a yearly laying period ($t=4.411$; $p<0.001$; $df=37$) (*Fig. 3*). This may indicate that the bird requires increasingly longer periods to lay successive eggs. Variability in the intervals between successive eggs in a laying period occurs from year to year. For example, in 1978 when Hirakawa laid 9 eggs there were 3 intervals of 3 days, one of 4 days, 3 of 6 days and one of 8 days. By contrast, when Hirakawa laid 10 eggs in 1981 there was one interval of 3 days, 2 of 5 days, 4 of 6 days, one of 7 days, and one of 11 days. Variables such as the preceding winter's weather, which might influence the bird's physical condition upon entering the breeding season, may account for some of this yearly variation. In 4 of 5 years, the longest interval occurred between the penultimate and final egg, and may be useful in anticipating

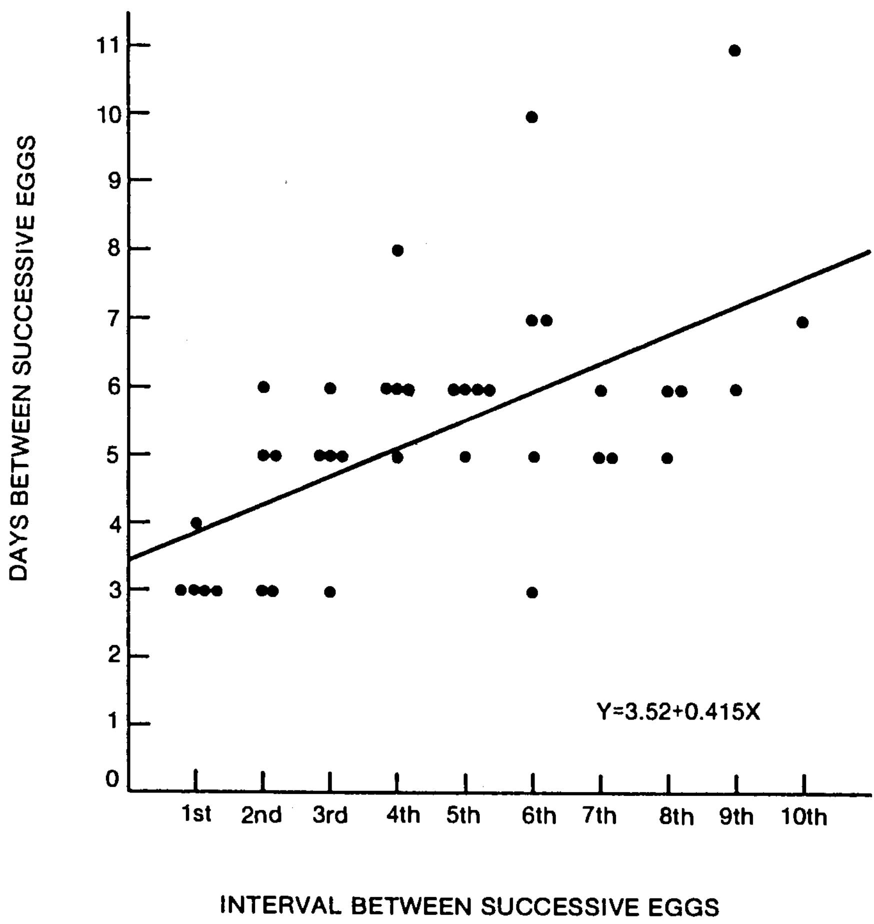

Fig. 3. The interval between successive eggs within a year increases throughout the laying period. Data for Hirakawa from 1978-1982. $t=4.41$; $p<0.001$; $df=37$.

the cessation of laying. The mean interval between the first 7 eggs of each year did not increase significantly with the age of the female ($t=1.799$; $0.10 > p > 0.05$; $df=28$) (*Fig. 4*). This suggests that double-clutching does not tax the female to the extent that she is impaired in producing eggs in subsequent years.

A trend was found in which the weight of successive eggs decreased significantly throughout a given yearly laying period ($t=6.492$; $p < 0.001$; $df=40$) (*Fig. 5*). Inspection of *Fig. 5* reveals a dramatic drop in weight between the first and second eggs which constitute a normal clutch. Thereafter, egg weight rebounds somewhat and then declines more gradually as the hen shifts from laying normal two-egg clutches to somewhat regularly spaced one-egg clutches. However, mean egg weight for the first 7 eggs for each year was found to increase significantly with the female's age ($t=3.185$; $0.01 > p > 0.001$; $df=33$) (*Fig. 6*).

Changes in egg shape as a function of egg sequence and changes in mean egg shape a function of age and of the number of eggs laid in a year were examined. Egg shape is represented by a numerical elongation value obtained by dividing egg length by egg width, a value of 1.00 representing a sphere. Hirakawa's eggs had elongation values ranging from 1.45-1.63. Her eggs became significantly rounder throughout a given laying period ($t=5.094$; $p < 0.001$; $df=41$) (*Fig. 7*). Inspection of *Fig. 7* reveals a pattern in which eggs become rounder correlated with the pattern of decline in egg weight within a given laying period. The second egg is appreciably rounder than the first egg in the first clutch. Thereafter the third egg is more elongate than the second egg with subsequent eggs becoming rounder more gradually. Or subsequent eggs may simply become rounder throughout the female's laying period (see data for 1980 in *Fig. 7*). The increasing roundness of successive eggs may be due to a gradual increase in the bore of the oviduct: the oviduct may not contract completely after being stretched by the passage of each successive egg. However, yearly mean egg elongation did not change significantly with the bird's age ($t=0.737$; $0.50 > p > 0.40$; $df=41$) (*Fig. 8*). From this it can be seen that although the oviduct may become stretched throughout a given laying period, it has resumed its normal shape by the next breeding season. This is not surprising for a seasonal breeder such as the Siberian Crane, where the size and weight of the reproductive tract is greatly diminished outside the breeding season. From the trend observed in *Fig. 7* whereby successive eggs become rounder throughout a given laying period, one might expect yearly mean egg elongation to decrease as a function of the number of eggs laid in a year. However, this trend was not apparent in our data ($t=0.847$; $0.50 > p > 0.40$; $df=41$) and may be due to the large variability and spread of data among years, even though eggs become rounder within any given year.

In summary for Hirakawa, the interval between successive eggs increased throughout a given laying period during which the eggs became lighter and rounder. Yearly mean egg weight increased with age, but mean elongation and the mean interval between eggs did not change significantly.

Incubation and Hatching

Attempts in 1978 and 1980 to incubate Siberian Crane eggs artificially resulted in no hatching of fertile eggs owing to deaths of embryos in late stages of development. Better results were obtained in 1981 and 1982, when the eggs were placed under incubating surrogates. In 1981, two chicks hatched, one dying 12 hours after hatching. The embryo of the third fertile egg died about midway through incubation. In 1982 four chicks hatched, the embryo of the fifth fertile egg dying somewhat before midincubation. The two embryonic deaths in 1981 and 1982 are thought to have resulted from inattentiveness on the part of the surrogates.

The incubation period for each of six Siberian Crane eggs was 29 days. Upon discovery, these eggs were immediately placed under surrogates, but had in some instances been incubated for at most 15 hours by Hirakawa before detection. The time at which chicks started scratching at the inside of the egg at the onset of hatching was recorded for two eggs

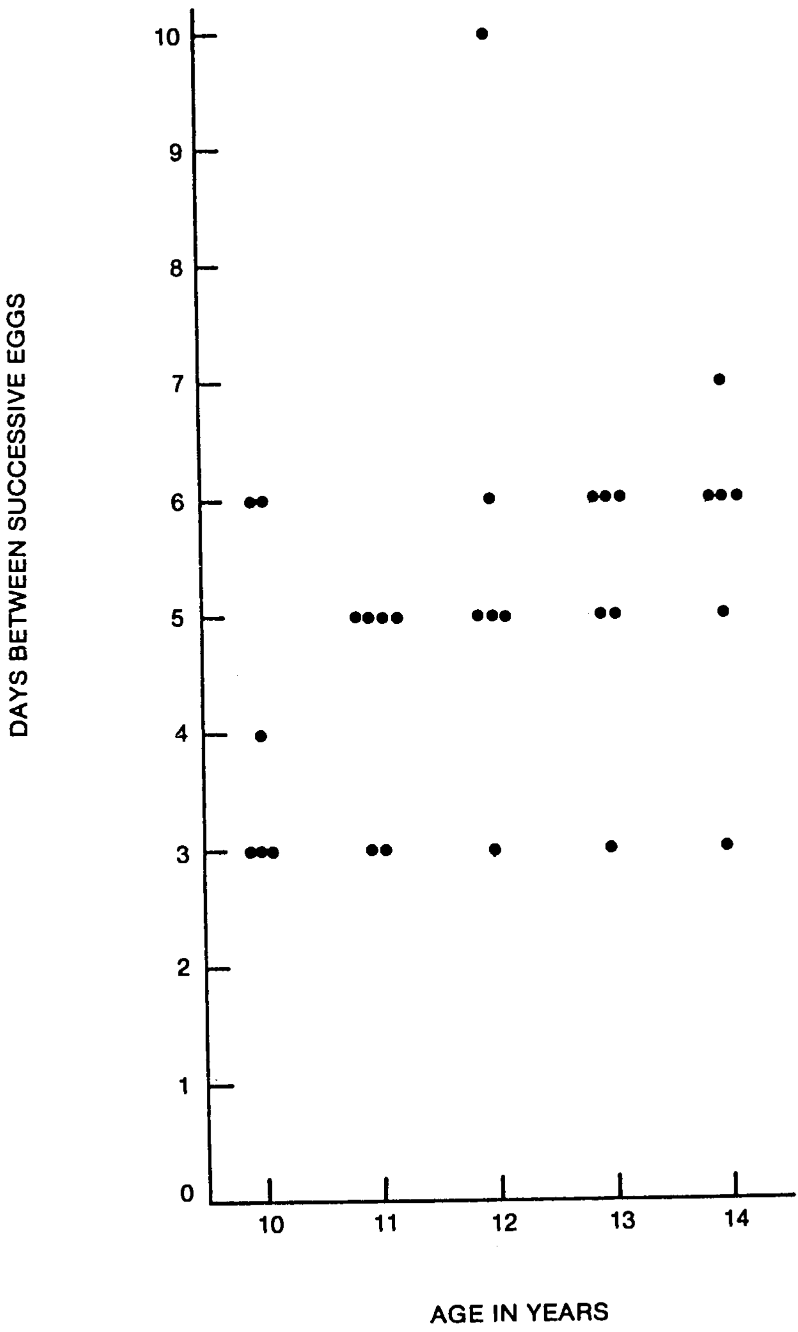

Fig. 4. A comparison of the mean interval between successive eggs and the age of the female. Data for Hirakawa from 1978-1982. No statistically significant relationship, $t=1.799$; $0.10 > p > 0.005$; $df=28$.

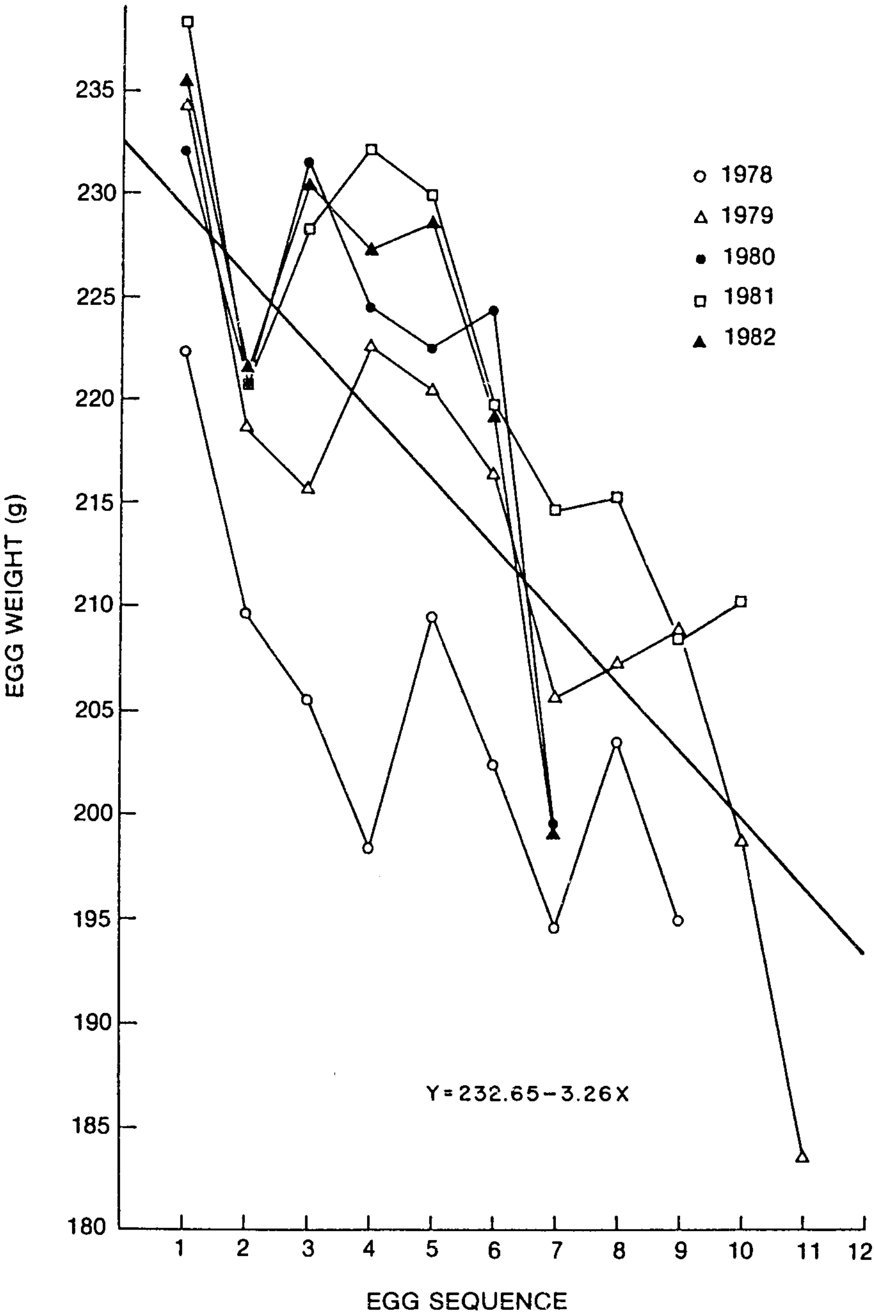

Fig. 5. Egg weight decreased throughout the laying period. Data for Hirakawa from 1978-1982. t=6.492; $p < 0.001$; df=40.

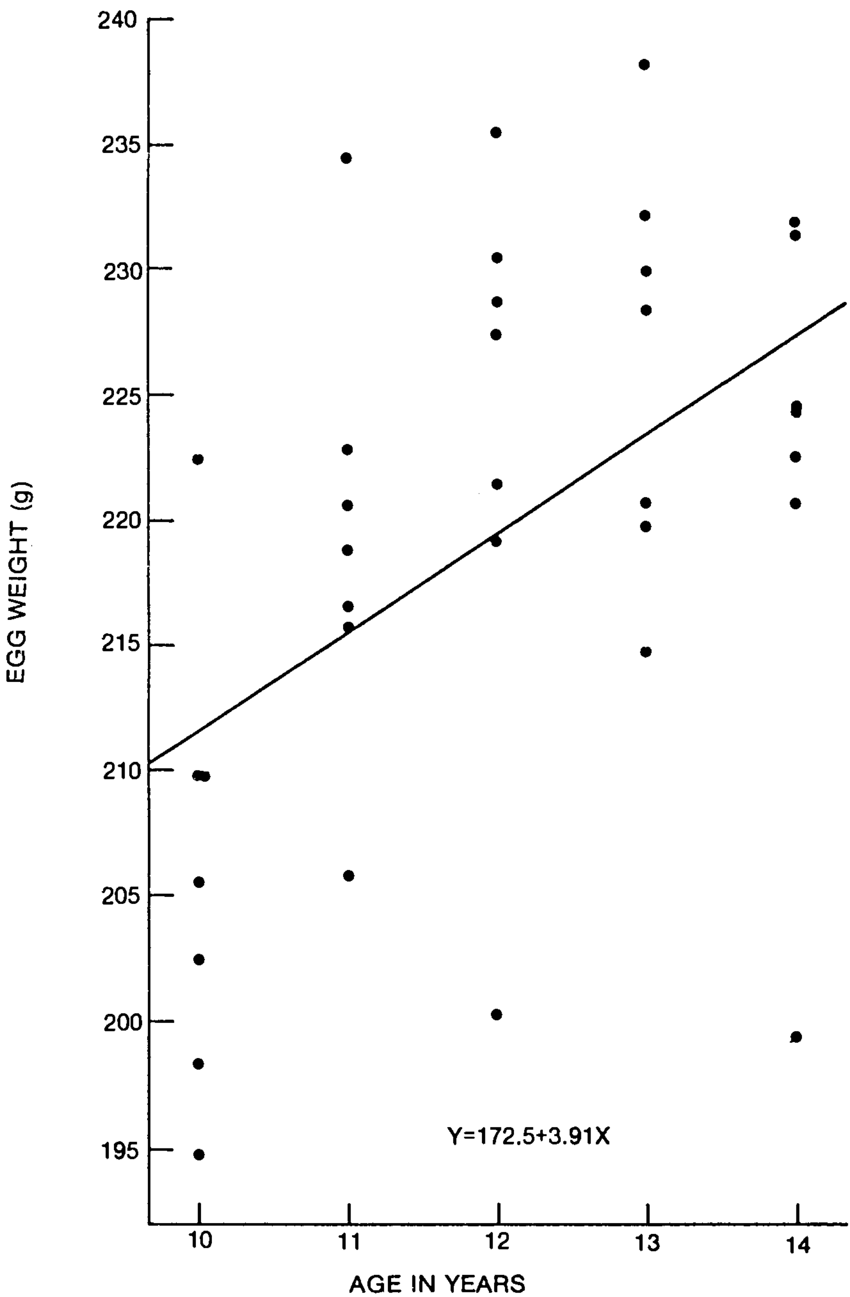

Fig. 6. Yearly mean egg weight (of the first 7 eggs) increases with the age of the female. Data for Hirakawa from 1978-1982. $t=3.185$; $0.01 > p > 0.001$; $df=33$.

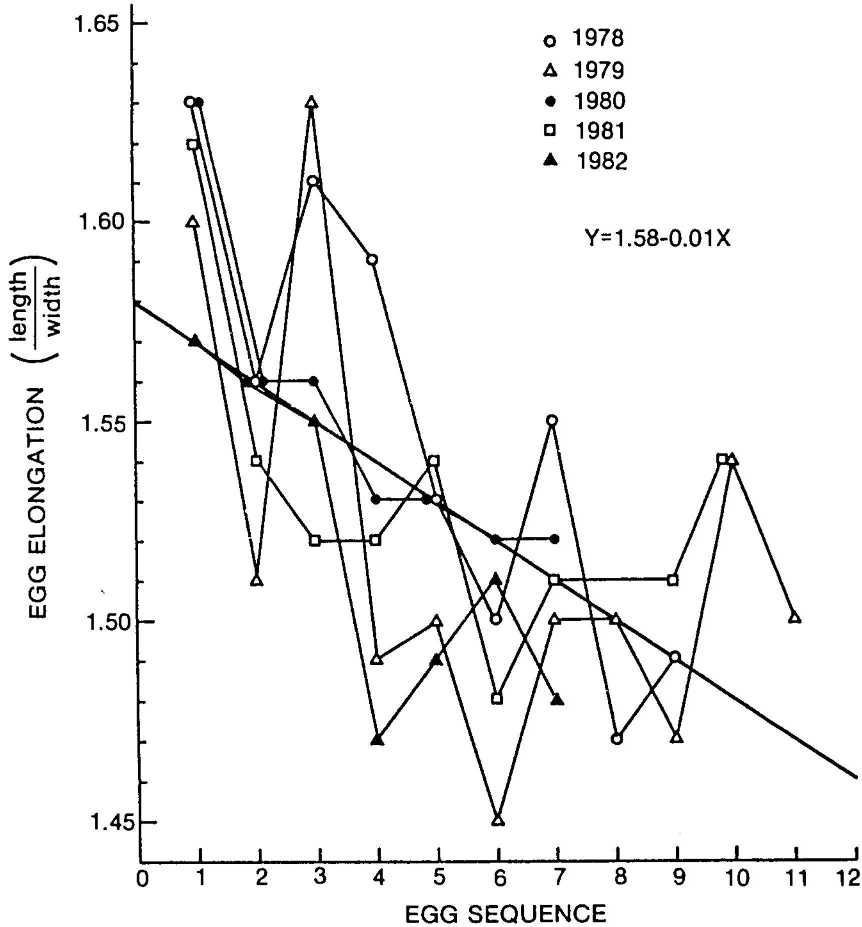

Fig. 7. Egg elongation (egg length ÷ egg width) decreases throughout a laying period. Data for Hirakawa from 1978-1982. $t=5.094$; $p<0.001$; $df=41$.

(1982, eggs #2 and #3) at 1700h of the 27th and 28th days of incubation respectively. The chick that began scratching on the 27th day had torn the inner shell membrane by 0800h of the 28th day and could be heard calling from within the eggshell. Two other chicks (1982, eggs #1 and #6) were heard calling from within their shells on day 28 of incubation. All chicks in 1982 failed to pip their shells. Human attendents artificially pipped these eggs and assisted these chicks with the remainder of the hatching process. The two eggs hatched in 1981 (#8 and #10) both pipped on the 28th day of incubation. Of these, only the chick from egg #10 completed the entire hatching process without help and emerged 16.5 hours after pipping.

Growth and Development of Chicks

Siberian Crane chicks are covered with long cinnamon-colored down. Their down is noticably longer than that of chicks of other species from more southerly latitudes. The down covering what will later be the bare facial skin of the adult is much shorter than the rest. The chicks have ice-blue eyes at hatching; they later change to the adult yellow.

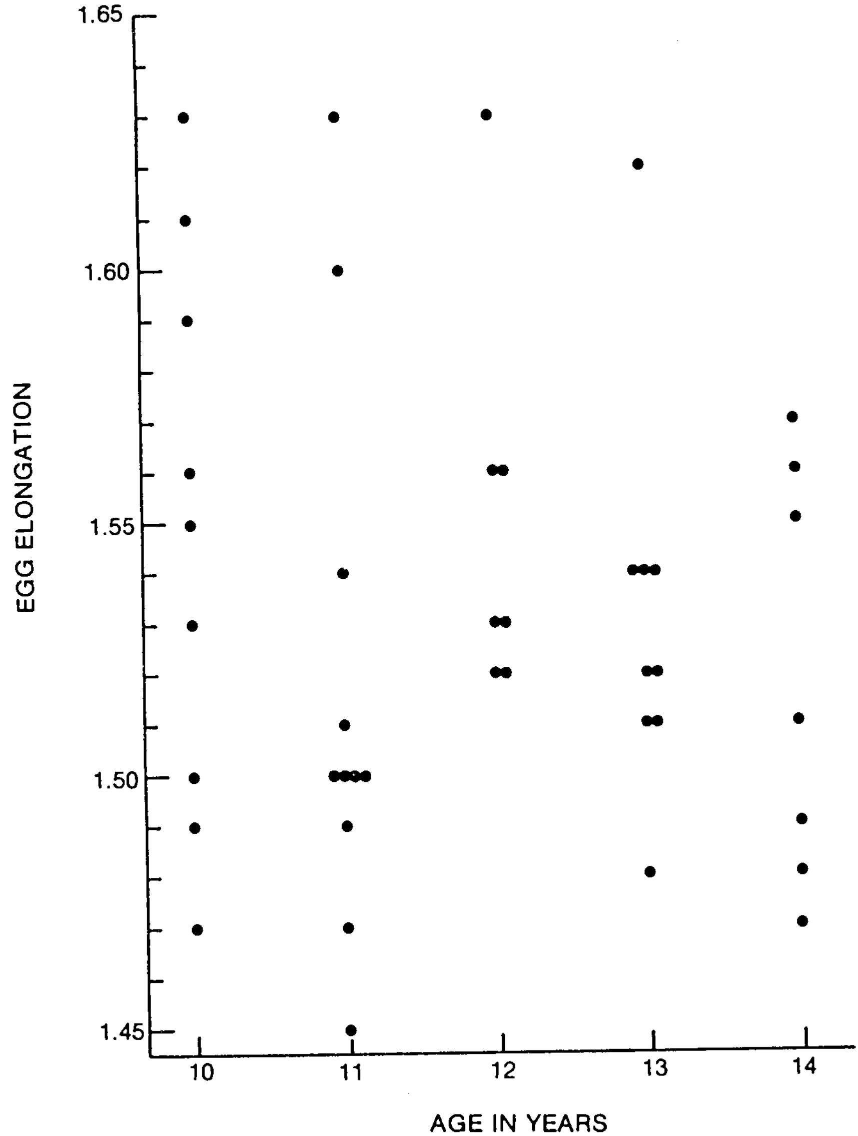

Fig. 8. A comparison of yearly egg elongation with the age of the female. Data for Hirakawa from 1978-1982. Not statistically significant, t=0.737; 0.50 >p >0.40; df=41.

The voice of Siberian Crane chicks differs from that of other crane species. All other species make some form of a 'peeping' call as chicks, whereas the Siberian Crane has a raspy whistled call. Although most crane chicks exhibit some aggression toward siblings, in our experience Siberian chicks are the most aggressive both toward conspecifics and chicks of other species and the aggression persists longer than in other species. Extreme vigilance was required when one or more Siberian chicks were exercised with flocks of other chicks. Siberian Chicks have on at least one occasion injured other chicks to the point of requiring medical attention.

Siberian Cranes grow rapidly after an initial weight loss during the first few days after hatching (*Fig. 9*). The initial weight loss occurs during the first four days after hatching and by day five all chicks show gain. Days four through 30 are a crucial period in which too rapid a weight gain may result in leg deformities. The weight change for ten Siberian chicks (185 measurements) from day four to day 30 is expressed by the equation: $S_t=76.5 \times e^{0.0946t}$, where S_t is chick weight at age t, and t is age in days (*Fig. 10*).

The results of our experiment in isolation rearing (see Methods for procedures) of crane chicks are rather incongruous. The Blue Cranes that were isolation-reared in 1981 were quite afraid of human beings (Putnam 1982), as were Red-crowned Cranes isolation-

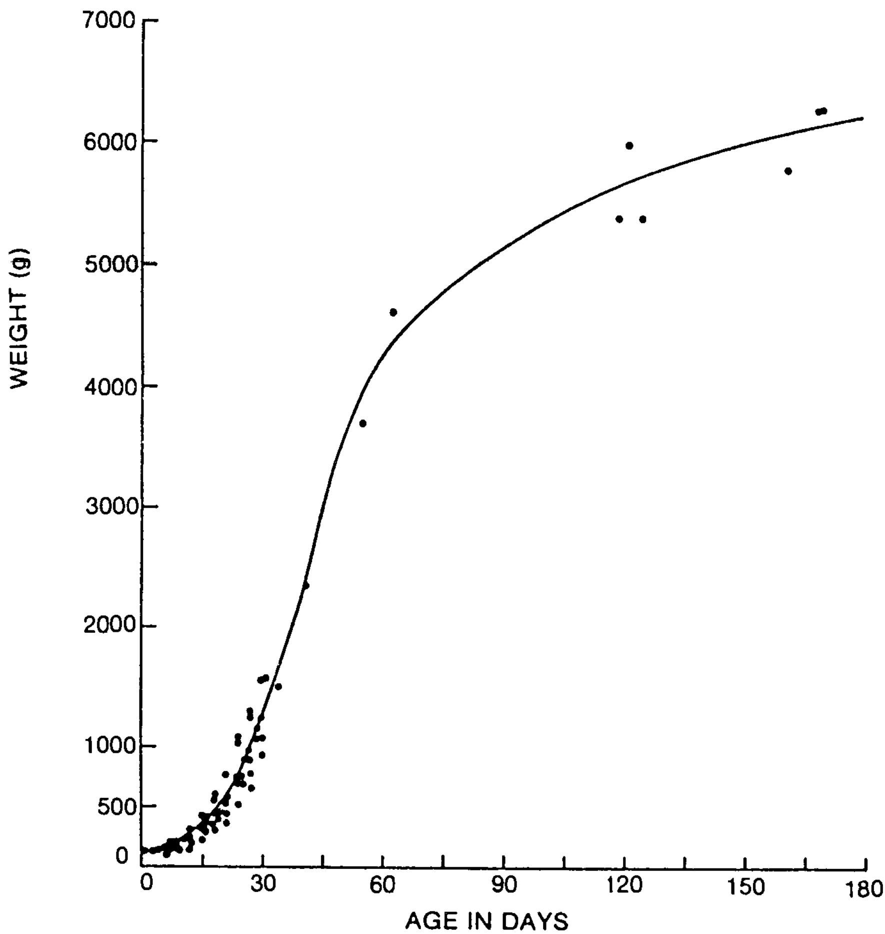

Fig. 9. Weight gain for captive Siberian Cranes from Hatching to 169 days of age. Slope hand drawn from representative points from 220 measurements of 10 birds.

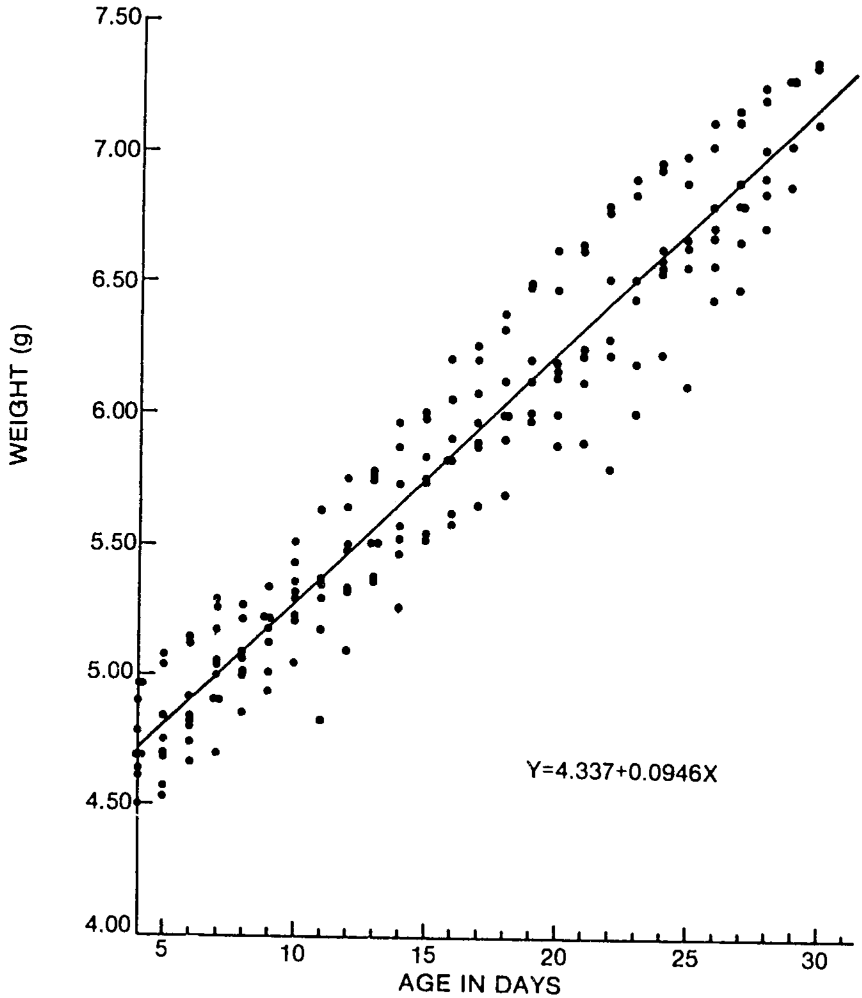

Fig. 10. Weight gain for captive Siberian Cranes from 4 to 30 days of age. Slope derived from 185 measurements of 10 birds.

reared in 1982. At first, the isolation-reared Siberian chicks were afraid of human beings and ran to a distant part of the outdoor unit when approached by people. After about one week, however, these birds became increasingly interested in people and were soon exhibiting food begging behaviour towards them. These birds continue to interact socially with people and behaviourally are apparently indistinguishable from regularly hand-reared cranes.

Siberian Crane juvenile plumage is largely rust-colored, becoming suffused and eventually replaced with the white adult plumage by late in the bird's second year. The chick raised in 1981 first flew at 76 days of age.

The age of sexual maturity of Siberian Cranes remains uncertain. Hirakawa first laid eggs at ten years of age although she had been without a mate prior to that time. As of 1983, two females six years old had not begun egg laying. One of three males five years old began steady semen production in 1983. Two of these males produced a rare semen sample, usually containing few sperm, when four years old. The longevity of wild Siberian Cranes is unknown. Similarly the ultimate longevity of captives is unknown, although they appear to be quite long lived. One male (Wolf) at ICF is rumored to have been brought into captivity around the time of World War I; however, this requires confirmation. Flower (1938) reported one Siberian Crane that lived 32 years and another still alive after 36 years in captivity at the London Zoo. He also reported birds still living in captivity at the Rotterdam and Philadelphia Zoos after 30.5 and 33 years respectively. Davis (1969) reported the death of a Siberian Crane that had been at the National Zoological Park, Washington, D.C., for 61 years, 8 months, and 26 days before being killed by vandals.

Mortality and Illness

From 1976 to 1983, one adult and three chick Siberian Cranes died at ICF. An adult female (Philis), as noted above, was killed by her mate, apparently a result of redirected aggression when a third Siberian Crane came into visual contact with this pair. One chick hatched from an egg collected from the wild in 1977 died of an impacted crop, a condition that arose when the bird ingested fibers it pulled from a carpet covering the floor of its brooder. This problem was corrected by switching to an artificial sod flooring which has fibers firmly embedded in a rubberized backing. A second chick died in 1981, 12 hours after hatching, of an intestinal infection of *Eschericia coli* which probably followed inadequate incubator hygiene. Subsequently, incubator disinfection was more thorough and repeated more often. A third chick, older than the two previous (downy) chicks, died from complications resulting from a leg abnormality due to rickets. This 1982-hatched bird developed a rotation and outward bowing of the left tarsometatarsus. The bird received calcium/phosphorous/vitamin D supplements in tablet form in an attempt to correct this condition but it failed to improve. A later treatment, trying to correct bone placement by wrapping the leg, caused the bird to fall and shatter its left femur. The bird died after surgery to repair the femur. This bird was one of four Siberian Cranes reared in isolation units that year and the initial rotation of the leg may have resulted from insufficient exercise. The bird was removed from isolation and encouraged to exercise after the condition was first detected, but remedial action came too late to be of consequence.

Anatomical abnormalities and injuries account for the majority of veterinary problems encountered, particularly involving the legs. One chick (Kyta), from an egg collected in Siberia in 1977, hatched with spradled legs. The legs were repositioned using a small harness that pulled the legs in toward each other while still allowing the bird to walk. Once the legs appeared to be correctly positioned and stable, the harness was removed. This bird has recurrent episodes of limping affecting either leg, though never both legs simultaneously. On each occasion the tibiotarsal-tarsometatarsal joint becomes inflamed and swollen. Various antibiotic treatments have been tried with the most recent being 1cc lincomycin (100mg/ml) injections given directly into the joint from a frontal approach. Hot compresses were also applied several times daily. Small amounts of fluid were drained on some occasions. Seemingly irrespective of the type of treatment, most episodes of limping improved after about one week. Another female (Tanya) was treated with a general antibiotic on the one occasion she was limping with an inflamed left tibiotarsal-tarsometatarsal joint. A subadult male (Eduard) broke a tendon in his left foot that controlled closing and spreading the toes with each step. The injury was allowed to mend without treatment. After months of favoring that foot, this bird has learned to accommodate the handicap by walking slowly. Another anatomical abnormality is found in a male (Bazov) that hatched from an egg collected late in incubation from the wild. From hatching, this bird has had the distal portion of each mandible slightly crossed with the other but affords the bird no difficulties. Hirakawa suffered a partially prolapsed oviduct with the laying of her final egg in 1979. The oviduct was disinfected and reinserted without any lasting ill effects. She resumed normal egg-laying the following year.

Two types of parasites have been successfully treated for in postfledging young of the year. Gapeworms (*Syngamus trachae*) were treated with a commercial preparation containing thiabendazole (50mg/kg in water) with two treatments administered a fortnight apart. Roundworms (*Ascaridia galli*) were treated by administering piperazine citrate tetrahydrate (28.4g in 531 of water) daily for six days.

DISCUSSION

After a long history in captivity, Siberian Cranes were first successfully bred in captivity in 1981 and again in 1982. Despite this initial success several challenges lie ahead. One important requirement is to coordinate semen availability to the females' laying cycles. Many eggs in past years remained unfertilized owing to the unavailabilty of high quality semen. A possible approach here might include modified techniques for handling males during collection; another approach might seek to develop and refine techniques for freezing semen, such that it could be stored during periods of peak production and saved for later use. Still another approach might involve placing carefully selected pairs in oversized pens, where the females would have sufficient room to escape the males' aggression and allow natural copulation. This approach may not be as successful as one might guess, since a number of compatible egg producing pairs have refused to copulate in captivity. The only attempt at housing a pair of Siberian Cranes together at ICF (1977-1978) resulted in the death of the female. That same year, the male of a pair at Olney Flamingo Gardens and Zoological Park, Great Britain, killed its mate (C. Marler, pers. comm.). Zoo records reveal a suspicious preponderance of males suggesting that the survival of females in captivity is less than of males. Although this imbalance may be partially attributable to incorrectly sexed birds, there is also the possibility that males may have killed the females, as happened at ICF.

Another aspect of management requiring additional work is the incubation of eggs. Efforts prior to 1981 to incubate Siberian Crane eggs artificially failed; hatchability for other species was also low. Improvements in artificial incubation in 1981 and 1982 were not applied to Siberian Crane eggs, as they were for the most part incubated by surrogates. Further attempts at artificial incubation of Siberian Crane eggs should be made in the future to allow a better comparison with surrogate incubation. The chicks hatched in 1981 and 1982 resulted from surrogate incubation, to be sure; nevertheless, at least one embryo in each of these years, as well as in 1983, died during such incubation. Adjustments in managing surrogates should be attempted in order to decrease these losses. It is worth noting that embryo mortality under surrogates occurred in the early to middle stages of development, whereas incubator mortality occurred late in development.

The premier challenge in the veterinary management of Siberian Cranes is the prevention and treatment of leg problems. Controlling early weight gain in chicks is important in preventing the development of leg abnormalities. However, should leg problems arise in either chicks or adults, completely effective treatment is still lacking.

Perhaps the greatest difficulty in managing the small captive population is related to its genetics. Inbreeding and genetic drift are hazards facing all small populations. Maintaining the loss of heterozygosity due to inbreeding to less than one percent per generation requires an effective population of 50 or more individuals (Soule 1980). Effective population refers to the number of *breeding* individuals, hence an entire captive population may have to be much larger than 50. It is further required that the breeding system entail substantial panmixis and that each member contribute equally to the next generation. The number of captive individual Siberian Cranes available for formation of a founding population is comparable to or larger than the founding captive populations of other endangered crane species. However, as of the end of the 1983 breeding season, the effective breeding population of captive Siberian Cranes was three individuals. Goals for the genetic management of this captive population should include "persuading" as many individuals as possible to breed, managing crosses to achieve an equal contribution from each breeder, and insuring sufficient gene flow between the various captive populations.

Attainment of these goals would be greatly aided by the formation of a studbook listing all captive individuals, their origins, lineages, and addresses. Such a studbook should have a permanent repository and be updated annually. A studbook would allow for proper exchanges of birds among institutions and would, it is hoped, encourage the crossing of unmated individuals.

The question whether the disjunct eastern and western populations should be managed as separate populations, each represented in captivity, has been put forward. Numerous factors should be considered in approaching a decision. The disjunction of these populations has probably arisen in historical times owing to extirpation by man of intervening populations. If there is no gene flow at present between these populations, it probably ceased only in recent times; given the long generation time in cranes, the two populations may not have diverged significantly. However, Corbin (1978) suggests that marginal populations may tend to be less heterozygous than central populations and may be exposed to different selection pressures. If Corbin's conclusions are applied to the very small size of the western population, in which considerable drift may already have occurred, considerable dissimilarity may exist between eastern and western populations. The possibility of some gene flow between these wild populations still exists, given the dispersal abilities of Siberian Cranes and their poorly understood post-breeding movements. Corbin's (1978) review of recent work examining genetic distances among populations, subspecies and species in *Passeriformes* and *Procellariiformes* seems to show more genetic similarity among local populations of these birds than commonly found in other vertebrate classes. Corbin goes on to suggest that the origins of individuals used in repopulation schemes are not of major concern; he advocates using individuals that are similar ecologically. He also suggests that individuals from central populations having greater genetic variability may make better colonizers. Since no such central populations remain for Siberian Cranes, hybridization of eastern and western birds may increase the heterozygosity of individuals for reintroduction.

A more immediate problem to be dealt with, if it is decided to maintain separate eastern and western captive populations, is that few western individuals are presently in captivity and the small wild population may not be able to withstand the further collecting needed to bolster the captive population. Certainly more information is required before a decision is contemplated. Application of a variety of biochemical methods to measure genetic distances among eastern, western, and hybrid birds already in captivity should be employed. Investigations into the genetic distances between marginal and central populations of still common and widespread species such as Sandhill, Common, and Demoiselle Cranes would provide much useful information for the management of both captive and wild populations.

In analyzing Hirakawa's egg laying records a number of trends in the interval between successive eggs, in changes in egg weight, and in changes in egg shape were revealed. These data suggest that for Hirakawa no deleterious consequences of double-clutching appeared in the years 1978 to 1982. Comparable studies on wild cranes are unavailable for comparison. Similarly, few studies exist on double-clutching in other species in captivity. However, studies of some domestic and wild species other than cranes show similar patterns in changes in egg characteristics and intervals between eggs.

For Hirakawa, it was shown that intervals between successive eggs increased throughout a yearly laying period. In chickens, *(Gallus gallus)*, the interval between successive eggs within a laying cycle is shortest at the middle of the cycle and increases towards the beginning and end of the cycle (Atwood 1927). In most years, for Hirakawa the longest interval between successive eggs occurred between the final two eggs. In chickens, the longest interval is similarly between the penultimate and final egg (Atwood 1927). Atwood also reports that the mean interval between successive eggs increases with the hen's age. The main interval among the first seven eggs of each year did not increase significantly with Hirakawa's age.

The weight of Hirakawa's eggs decreased throughout the yearly laying period. If given a choice, it might seem preferable to use larger early eggs for reintroduction since chicks from these eggs would have a greater body weight and better survival than would later chicks. Later chicks might grow better in captivity, where they could receive special attention. Coulson, et al. (1969) report that Shags (*Phalacrocorax aristotelis*), Kittiwakes (*Rissa tridactyla*), and Great Skuas (*Catharacta skua*), devote less material to egg production as the breeding season advances. At least for Kittiwakes and Shags this trend is partially due to older females, which lay heavier eggs, laying earlier than young birds; although, for Kittiwakes, earlier layers generally produce larger eggs within a given age class (Coulson, et al. 1963). For female Shags up to eight years old and laying typical 3- or 4-egg clutches, the first egg is lightest, the last next lightest, and the middle egg(s) heaviest. However, in Shags over eight years old, the last egg is largest in 3-egg clutches (Coulson, et al. 1969). In captive Nene Geese (*Branta sandvicensis*), the first eggs in a clutch are lighter than subsequent ones. However, eggs of the second and third clutches average slightly lighter than those in the first (Kear & Berger 1980). Richdale (1955) found no difference in mean weight between the first and second eggs in 2-egg clutches of the Yellow-eyed Penguin (*Megadyptes antipodes*). Similarly, Romanoff & Romanoff (1949) report that egg weights for individual chickens vary within a fairly narrow range throughout the year. Egg weight increases throughout the laying season in Bobwhite Quail (*Colinus virginianus*) (Stoddard 1931). Finally, in Song Sparrows (*Melospiza melodia*) no trend is evident in egg weight in successive eggs within a clutch; either the first, middle, or final egg may be the heaviest. However, within a season given females lay later clutches of eggs 13% heavier than in earlier clutches (Nice 1937).

The mean weight of Hirakawa's first seven eggs in each year increased with her age. Older females are reported to lay heavier eggs than younger females in Song Sparrows (Nice 1937) and Gannets (*Sula bassana*) (Nelson 1966). In a number of other species mean egg weight increases up to some age, then declines with the hen's further increased age. In Yellow-eyed Penguins egg weight increases with age up to 13 years, thereafter declines (Richdale 1955). In Shags, egg volume increases from two to eight years of age (Coulson, et al. 1969). Mean egg weight increases with age in chickens up to two to four years of age, depending upon the breed, and subsequently declines. Captive Nene Geese laying multiple clutches show an increase in mean egg weight from two to four years, followed by a decline with further increased age (Kear & Berger 1980). One might expect a similar peak and then decline in mean egg weight in cranes, but given the long lives of cranes, many years of data may be needed to demonstrate them.

Hirakawa's eggs became successively rounder in a yearly laying period. Coulson (1963) reports that eggs laid in a population of Kittiwakes became more elongate throughout a laying season in part owing to older females, which lay broader eggs, laying earlier than younger birds. No regular increase or decrease in egg elongation was noticed in either Song Sparrows (Nice 1937) or chickens (Romanoff & Romanoff 1949).

The yearly mean elongation of Hirakawa's eggs did not change with her age. In Yellow-eyed Penguins, both egg length and egg width increase with age up to the age of 13 years, during which time egg weight also increases, but thereafter width remains constant and length decreases, hence the eggs become rounder. Eggs become rounder with increased breeding experience in Kittiwakes (Coulson 1963). Egg width increases with the number of times a female has laid in Short-tailed Shearwaters (*Puffinus tenuirostris*) (Serventy 1967). In Song Sparrows older birds lay wider eggs (Nice 1937). Conversely, Romanoff & Romanoff (1949) found that in chickens egg width was rather constant and that individual hens lay eggs more or less uniform in shape.

In measuring eggshell thickness for Hirakawa's eggs in 1981, Rogers (this volume) found a trend in which eggshells became significantly thinner throughout the laying period. She also suggests that hatchability was not affected by this decrease. In our analyses and comparisons with other species, no deleterious effects of double-clutching could be identified during the five years in question. Possible deleterious effects of double-clutching should be watched for in other individuals and other crane species for longer periods of time since any possible effects may not manifest themselves in the short term for these long-lived birds.

The results of rearing Siberian Cranes in isolation differ sharply from results obtained with other species. Red-crowned and Blue Cranes emerged from isolation quite afraid of human beings and did not subsequently interact socially with them. Siberian Cranes, initially afraid of human beings, soon overcame this and begged food from them even though they had been feeding independently for a month or more. These birds continue to interact socially with human beings. A report of a wild chick behaving similarly comes from Eduard Nazarov (pers. comm.). While studying Siberian Cranes on their breeding grounds, Nazarov left his tent one morning to find a pair of Siberian Cranes and their chick very nearby. The startled adults flew away leaving the chick. Nazarov's attempts to place the chick at a distance from his camp so that the adults might return for it were unsuccessful because the chick always followed him back, even following him into his tent. This chick was later sent to the Oka State Nature Reserve crane breeding center. Nazarov's experience as well as our attempts at isolation rearing of Siberian Cranes suggest that these birds are susceptible to a later age than other species of imprinting on human beings. There is no immediate explanation for this long impressionable period in Siberian Cranes.

Comparison of juvenile birds born in the same year in captivity and wintering in India revealed that wild birds acquire their white plumage sooner than captive birds. The molt of captive birds may be delayed by their remaining in a cold area during the winter; wild birds move to warmer areas. Siberian Cranes appear to become sexually mature later than other species, at least in captivity. It is unknown of what age wild Siberians first reproduce. Six year old females have yet to lay eggs; only one of three 5 year old males has consistently produced semen. Whooping Cranes (*Grus americana*) are similarly delayed in reproducing (Kepler 1977), wheras most other species reproduce by three years of age in captivity. How long Siberian Cranes remain reproductive is unknown. A male at ICF, believed to have been in captivity 60+ years, regularly produces semen and has fathered several young. Conway & Hamer (1977) reported a captive female Wattled Crane (*Bugeranus carunculatus*) that has laid throughout a 36 year span. Given the apparent longevity of Siberian Cranes and their ability to lay up to 11 eggs each year, large numbers of eggs should become available for reintroduction as the many subadult birds in the captive population reach maturity.

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A RECENT SURVEY OF 19TH CENTURY WINTERING SITES FOR SIBERIAN CRANES IN THE GANGETIC BASIN

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ABSTRACT

Between January 7 and 25, 1983, a survey was conducted in two areas of Uttar Pradesh in northcentral India where Siberian Cranes (*Grus leucogeranus*) had been seen in the 19th Century. While the main purpose of the survey was to look for these birds, we also gathered information on the current status of the shallow lakes in these areas, including their size, depth, incidence of human disturbance, and presence of *Cyperus rotundus*. No cranes were found, but villagers at one site reported seeing birds similar to Siberian Cranes two months earlier. The veracity of this report is discussed, as is the need to conserve habitat in western portions of the Gangetic Basin as alternative wintering sites for the Siberian Crane flock at Keoladeo National Park.

INTRODUCTION

The Siberian Crane (*Grus leucogeranus*) is an endangered crane species. Recent evidence indicates that fewer than 1500 individuals may exist (Flint & Kistchinski 1981, Zhou & Ding 1984), and populations that have been carefully monitored over the past 5 to 10 years have shown alarming declines (Sauey, this volume) (a), (Ashtiani, this volume). One of the continuing difficulties in the conservation of this species is that, despite its large size, conspicuous white plumage, and preference for open, shallow wetlands, the full extent of its range may still be undetermined. Since 1978, for example, several important discoveries have been made regarding the Siberian Crane's distribution: 1. Soviet biologists discovered a new breeding grounds near the Kunovat River in western Siberia (Sorokin & Kotyukov 1982), 2. Chinese researchers found over 1400 individuals wintering at Lake Poyang along the Yangste River in southcentral China (Zhou and Ding, this volume), and 3. a population long considered extirpated was discovered at Fereydun-Kenar, Iran (Sauey 1979). Moreover, a strong possibility exists that a third breeding population may yet be uncovered in extreme western Siberia or even west of the Ural

Mountains in the Bolsezemelskaja Tundra of northeastern Europe (Sauey, this volume (b)). Whether additional discoveries will be made in the future is an open question.

In the 19th Century, reports of wintering Siberian Cranes on the Indian subcontinent appeared with regularity in the ornithological literature. *Fig. 1* shows the location of most of these records, and roughly defines the species' former Indian range as a broad swath of northern India from northwestern Sind (now Pakistan) in the west, to the Darbhanga District of northern Bihar in the east (Ali & Ripley 1969). By far the largest majority of sightings, however, occurred in the Gangetic Basin, west of 84° E. Longitude in the present Indian state of Uttar Pradesh. In fact, A.O. Hume, the extraordinary British ornithologist and political founder of the Indian National Congress, considered records of this species elsewhere; e.g. in the Punjab and Rajasthan, and at Nagpur in northern Madhya Pradesh, to have been exceptional and probably descriptions of stragglers or migrants, rather than actual winter residents (Hume & Marshall 1881). Whatever the merits of this opinion, the fact remains that the only area where 19th Century ornithologists regularly and consistently encountered Siberian Cranes was in the Gangetic Basin, especially in a

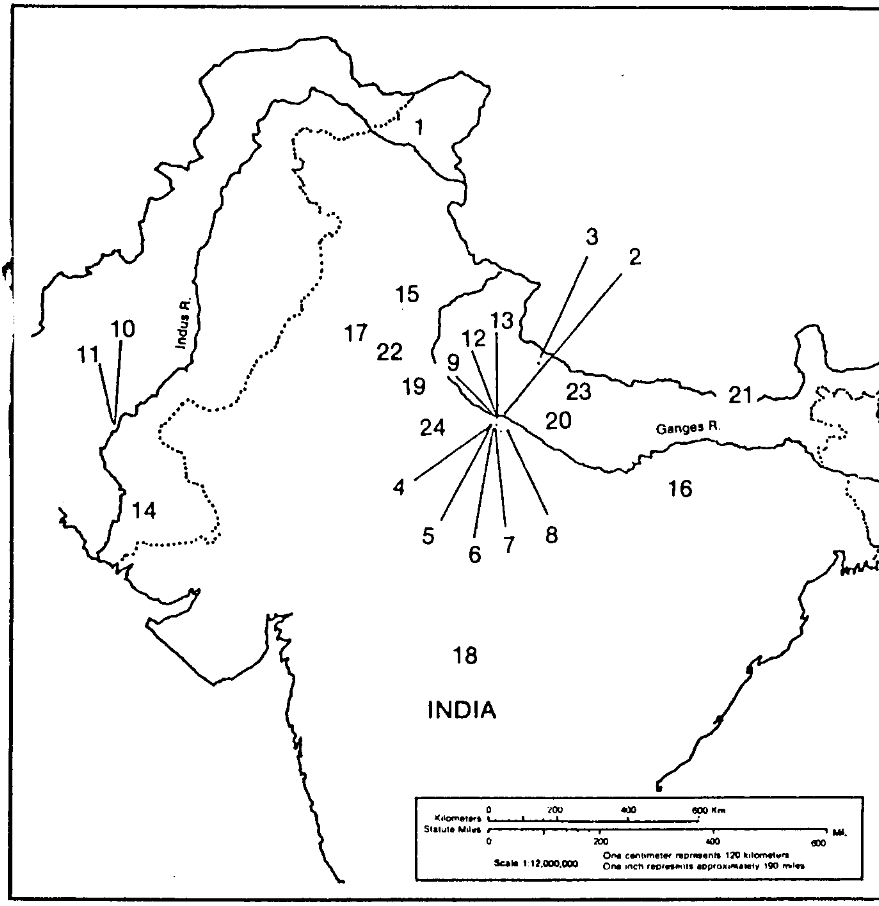

Fig. 1. Map of northern India and Pakistan showing sighting locations for Siberian Cranes prior to 1940.

Map Location # and Place Name	Coordinates	Date	Reference	Comment
#1. Leh, Ladakh	34.10N 75.35E	October, 1852	Hume 1868	Hume shot one, found it inedible.
#2. Sandi, U.P.	27.18N 79.57E	February, 1859	Irby 1861	Birds seen 4 times.
#3. Hilgee (Chowka R.)	27.22N 81.23E	December, 1859	Irby 1861	Birds seen 4 times.
#4. Etawah District	26.40N 79.02E	Winter, 1858-59	Hume 1868	Hume shot one out of of a flock of 25.
#5. Etawah District	26.40N 79.02E	Winter, 1865-66	Hume 1868	Hume saw many at different jheels.
#6. Etawah District	26.40N 79.02E	Winter, 1866-67	Hume 1868	Hume saw many at different jheels.
#7. Tuman Jheel	26.46N 79.02E	February, 1871	Walkinshaw 1973	W.E. Brooks shot 3 cranes.
#8. Indugurh (Indegarh) Jheel	26.56N 79.40E	January 30, 1871	Anderson 1871	Anderson reported jheel was "alive" with different birds.
#9. Fatehgarh	27.22N 79.38E	February 15, 1873	Walkinshaw 1973	Anderson shot a male.
#10. Guibee Dera (Langh)	27.23N 68.06E	No specific date.	Hume 1873	Natives did not recognize these cranes.
#11. Madho (Drigh)	27.36N 68.00E	No specific date.	Hume 1873	Natives did not recognize these cranes.
#12. Fatehgarh	27.22N 79.38E	December 6, 1874	Walkinshaw 1973	A. Anderson shot one female.
#13. Fatehgarh	27.22N 79.38E	December 31, 1876	Walkinshaw 1973	A. Anderson shot one female.
#14. Eastern Narra River	26.00N 69.00E	Winter, 1877-78	Butler 1878	Reported by Doig.

Fig. 1 (continued)

#15.	Kurnal (Karnal)	29.41N 76.50E	1864 & 3rd week of Oct., 1879	Hume & Marshall 1881	Earlier date by Jerdon.
#16.	Dehri	24.52N 84.11E	Oct. 6, 1879	Hume & Marshall 1881	Seen by W. Forsyth.
#17.	Hansi	26.06N 75.58E	No specified date.	Hume & Marshall 1881	According to Jerdon.
#18.	Koohee (near Kampti)	21.14N 79.12E	February 3, no year specified.	Hume & Marshall 1881	One shot by Col. McMaster.
#19.	Najafgarh Jheel	28.36N 77.12E	No specified date.	Hume & Marshall 1881	Jheel south of New Delhi.
#20.	Sandila	27.05N 80.13E	No specified date.	Reid 1881	5 cranes seen in shallow jheel.
#21.	Jaynagar (Jainagar)	26.38N 86.10E	Winter of 1898	Inglis 1903	Small flock seen.
#22.	Hisar	29.10N 75.43E	March 12, 1933	Walkinshaw 1973	W. Koelz shot one.
#23.	Payagpur Jheel	27.25N 81.48E	1937 (?)	Salim Ali (pers. comm.)	
#24.	Keoladeo Ghana (now Keoladeo Nat'l Park)	27.13N 77.29E	1937	Salim Ali (pers. comm.)	S.A. saw 11; shot one.

Fig. 1. (continued)

number of large "jheels" (shallow lakes formed in the monsoon) in northern Etawah and southern Mainpuri districts. It was here that Hume saw these birds repeatedly from 1859-1867 and collected over 20 specimens (Hume 1868) (*Fig. 2*).

At the present time, Siberian Cranes are known to winter in India only at Keoladeo National Park, previously called Keoladeo Ghana, the former exclusive hunting preserve of the Maharajah of Bharatpur (Sauey 1976). Keoladeo is located at the extreme western edge of the Gangetic Basin, about 150km west of Hume's Etawah-Mainpuri site. As far as we can determine, this sanctuary has been the sole Indian location for this species since the late 1930s, when Dr. Salim Ali saw a few of these birds in a jheel near Payagpur (*Fig. 1*, #23), also in the Gangetic Basin, but approximately 430km east of Keoladeo (Salim Ali, pers. comm.).

It isn't clear, however, whether the dearth of sightings since the 1930s is an indication of the complete extirpation of these birds from the basin (excluding the Keoladeo flock), or merely the failure of ornithologists to survey the area adequately. When asked this question, staff members of the Avifauna Project of the Bombay Natural History Society, India's principal center for ornithological studies, admitted that the basin was inadequately surveyed for migrant waterfowl, but contended that this severely over-populated region of India was unlikely to provide the required undisturbed habitat for these large and conspicuous birds (S.A. Hussain & Robert Grubh, pers. comm.).

The goal of this study, therefore, was twofold: 1) to look for this species at a number of sites in the Gangetic Basin where it had been seen in the 19th Century, and 2) to examine these and other sites to determine if such areas could adequately support a wintering population of Siberian Cranes.

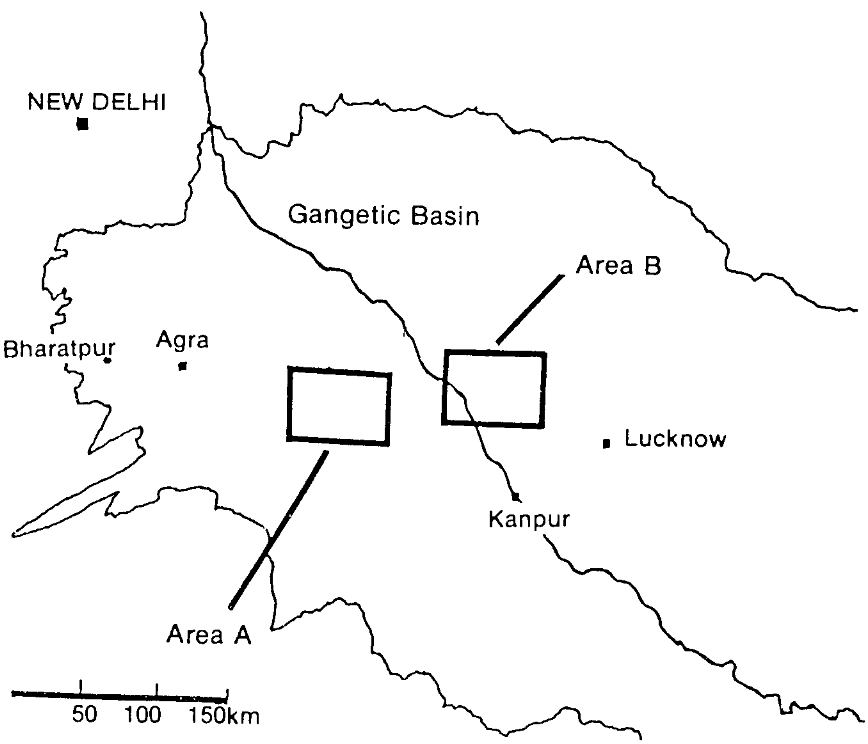

Fig. 2. Location of the two survey areas. Area A includes the Etawah-Mainpuri site described by Hume (1868).

METHODS

We chose to survey two areas within the basin that contained numerous jheels and included sites where Siberian Cranes had been reported in the past (*Fig. 2*). Each area consisted of approximately 1300km². Area A was located between the cities of Etawah [26.46N 70.02E] and Mainpuri [27.14N 79.01E] and included 6 jheels where Hume had made extensive observations on these cranes (Hume 1868) (*Fig. 3*). Area B was approximately 50km northeast of Area A and included the cities of Hardoi [27.25N 80.07E] and Kannauj [27.04N 79.55E]. Three jheels within area B were also locations of Siberian Cranes in the 19th Century (*Fig. 3*). We located these 9 jheels, as well as an additional 39, using topographic maps (1:250,000 scale, U.S. Army Corps of Engineers, 1955), as well as local gazateers (Neave 1910, Drake-Brockman 1911, Neave 1911).

Two of us (P. Das & V. Prakash) conducted the survey between January 7 and 25, 1983 by jeep. Altogether we visited 48 jheels. At each jheel, we filled out a report form that included a series of questions about the jheel's size and depth, the presence of aquatic vegetation, particularly *Cyperus rotundus*, the kinds and extent of human disturbance, the presence of waterfowl, and, of course, the presence of Siberian Cranes. Measurements and numbers were estimated, and parameters such as amount of disturbance were, naturally, subjective. Since the same two people surveyed all jheels, however, these opinions were considered adequate for the purposes of the study.

In addition, we carried a diagram (*Fig. 4*) showing two common bird species that might be confused with the Siberian Crane, the Sarus Crane (*Grus antigone*) and the Great Egret (*Egretta alba*), as well as a standing and flying representation of the Siberian Crane. A man in local dress was included for a size comparison.

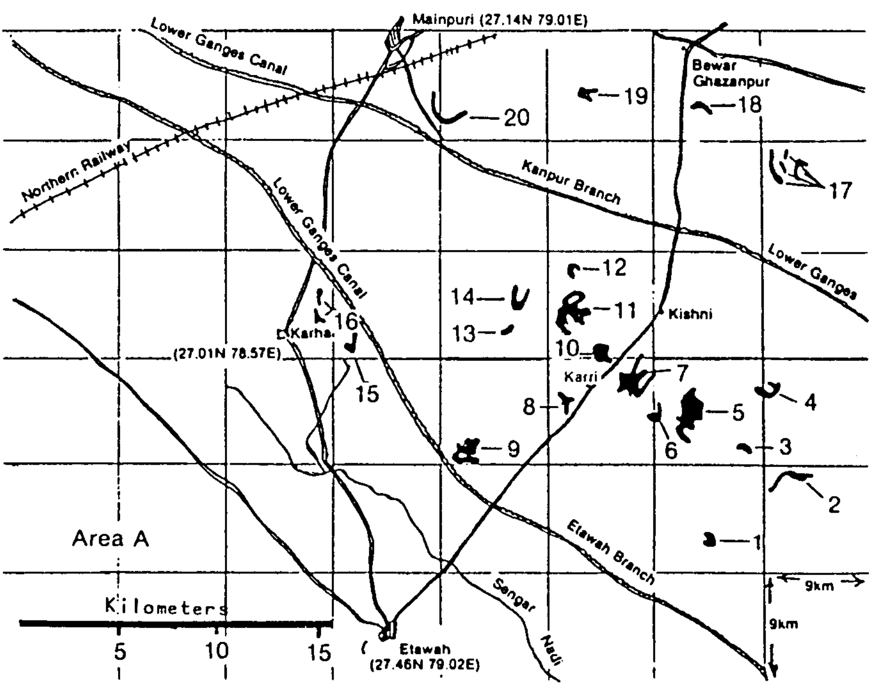

Fig. 3. Detail of survey areas A and B, showing the location of 45 of the 48 jheels surveyed (an additional 3 were found and described during the survey and are not shown).

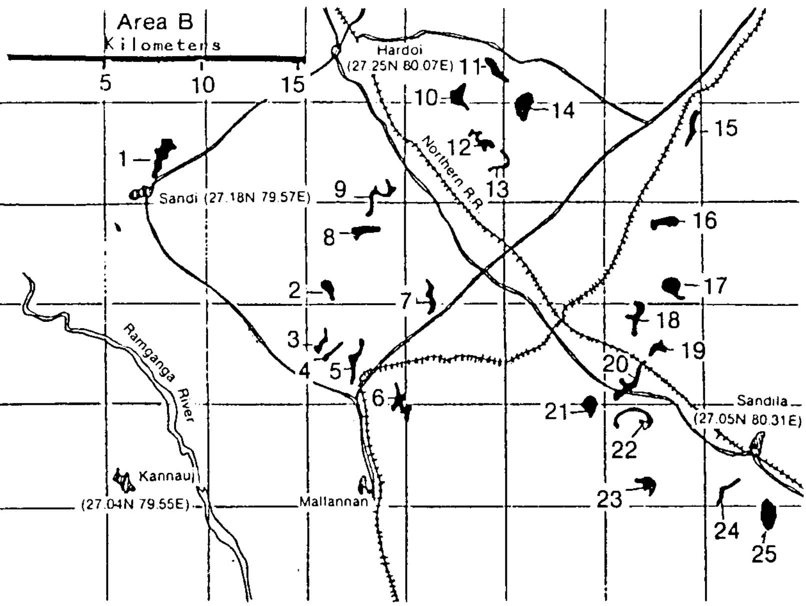

Fig. 3. continued from page 202.

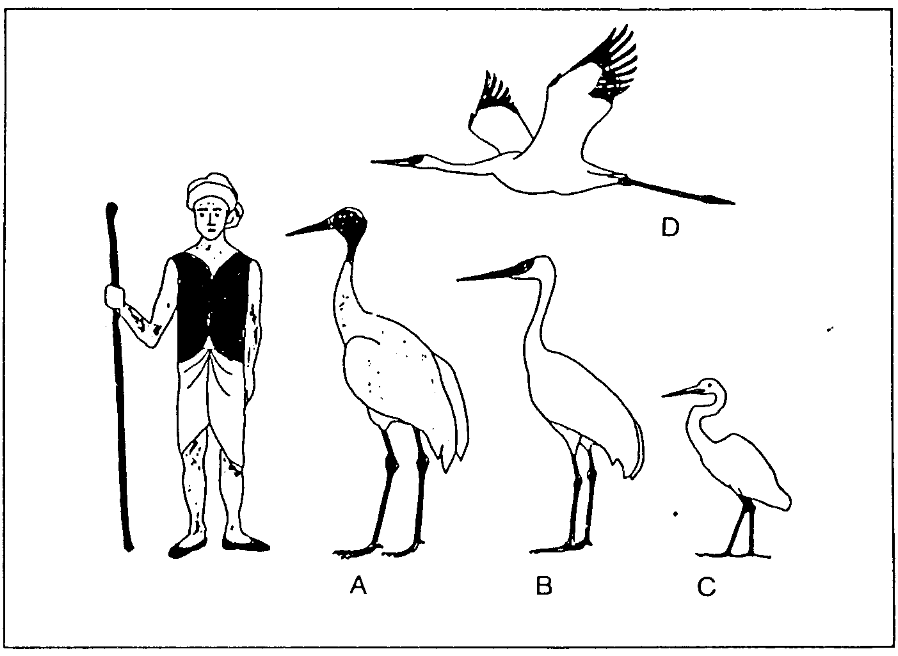

Fig. 4. Diagram used to determine local residents' familiarity with Siberian Cranes. A=Sarus Crane (*Grus antigone*), B=Siberian Crane, standing, C=Great Egret (*Egretta alba*), and D=Siberian Crane, in flight. Man in local dress is shown for size comparison.

RESULTS

No Siberian Cranes were found, nor, with one exception, did the local residents recognize this bird. *Fig. 5* shows other survey results. Jheels ranged from .3 to 6.5km² in area, and from .3 to 2.0m in depth, though some jheels were completely dry. All jheels were disturbed to some extent since standing water is a prime resource in India for many different activities. These disturbances included drainage for agriculture, swimming, washing, bathing, and fishing. Of more concern to us was the frequent incidence of shooting and trapping, the latter done by mist nets for waterfowl and small birds. Shooting was even more common, occurring in 80% of the surveyed jheels, despite its official prohibition. Waterfowl were present in numbers in only a few places, probably because of the unrestrained hunting; 42% of the surveyed jheels had no waterfowl at all. Finally, we found

SURVEY QUESTION	NUMBER OF JHEELS (% of SURVEYED)
1. Size of Jheel	
a. large (more than 4km²)	8 (17)
b. medium (1 - 4km²)	23 (48)
c. small (less than 1km²)	17 (35)
2. Depth of Jheel	
a. deep (1.5m and above)	14 (29)
b. shallow (less than 1.5m)	25 (52)
c. dry or nearly dry	9 (19)
3. Incidence of Drainage	
a. heavily-drained	12 (25)
b. moderately-drained	25 (52)
c. slight or no drainage	11 (23)
4. Incidence of Disturbances of All Kinds	
a. heavy	21 (44)
b. moderate	20 (42)
c. light	7 (14)
5. Presence of *Cyperus rotundus*	
a. abundant	7 (14)
b. scarce	9 (19)
c. absent	32 (67)
6. Presence of Migratory Waterfowl	
a. many	11 (23)
b. few	17 (35)
c. absent	20 (42)

Fig. 5. Summary and tabulation of questionnaire results.

Jheel Name	Lit. Reference	Jheel # In Survey Area & Coordin. (*see fig.*)	Estim. Dimension Size (km²)	Depth (m)	Dis.[1] Incid.	Dis.[2] Type	Presence[3] of *Cyperus rotundus*	Other[4] Water-fowl	Comments
Mohri-Sothna	Hume 1868	A-5 26.56N 79.17E	3	2	H	SFD	N	F	popular duck hunting spot
Sauj (Soj)	Hume 1868	A-13 27.01N 79.08E	4	2	H	SFD	S	F/M	much hunting, excel. habitat
Kurree (Lokpur)	Hume 1868	A-8 26.57N 79.10E	.7	.5	H	D	S	N	
Sarsai-Nawar	Hume 1868	A-7 26.58N 79.15E	4.5	1	H	STF D	S	F	once a prominent area jheel; much reduced
Bahmanpur (near Soj)	Hume 1868	A-14 26.02N 79.09E	.5	.3	H	D	N	N	almost completely drained
Pharenji	Hume 1868	A-10 26.59N 79.13E	.5	.6	H	D	N	N	almost completely drained
Dahar (Sandi)	Irby 1861	B-1 27.19N 79.59E	5	1	M	FD	A	A	
Sheoja	Reid 1881	B-21 27.06N 80.22E	2	1.5	H	STF D	S	S	
Gaundial	Reid 1881	B-23 27.02N 80.24E	3	2	M	SFD	S	S	

1. Disturbance Incidence
   H=heavy
   M=moderate
   L=light
2. Disturbance Type
   S=shooting
   T=trapping
   F=fishing
   D=drainage
3. Presence of *Cyperus rotundus*
   A=abundant
   S=scarce
   N=none
4. Presence of Other Waterfowl
   M=many
   F=few
   N=none

Fig. 6. Questionnaire results for 9 jheels in which Siberian Cranes were seen in the 19th Century.

Cyperus rotundus, the primary food plant of the Siberian Crane at Keoladeo, present in quantity at only 14% of the jheels. It was completely absent in 67% of the surveyed jheels.

Fig. 6 shows in more detail the current status of the 9 jheels that once harbored Siberian Cranes. All but two of these were heavily disturbed, usually by a variety of activities, but most commonly by shooting. Three had been almost totally drained and supported no waterfowl whatsoever. *C. rotundus* was either scarce or absent from 8 of the 9 jheels, only Dahar Jheel having the plant in good numbers.

DISCUSSION

It was disappointing not to find these jheels rife with Siberian Cranes, but not at all surprising. These birds were rare even in Hume's time, and the intervening century, with its explosion of human numbers, its technological improvements on agriculture and land reclamation, and its widespread use of high powered and accurate rifles, could not have improved their survival chances. More discouraging, perhaps, was the fact that the crane was not recognized by the local inhabitants, some of whom were old *shikars* and trappers with long and extensive familiarity with the area's migratory waterfowl. In only one case did the diagram picturing the Siberian Crane elicit a positive response. Several people near Narayanpur [27.07N 79.22E], the site of a series of jheels, said they recognized the bird and that a flock of some 3000 to 4000 passed over the village during the last week of November, 1982. Although such large numbers would seem to automatically invalidate the report, the villagers interviewed were knowledgeable about birds in general, and called the Siberian Crane "kulang," a vernacular name generally used to describe migratory cranes in northern India. A number of explanations might account for this report, the most optimistic being that these villagers actually saw a flock of Siberian Cranes and exaggerated the numbers to impress their inquisitors. A more reasonable explanation, however, is that these birds were indeed "kulang," but the much more numerous and widespread Common Crane (*Grus grus*). In strong light, these light grey cranes, expecially in flight, look white, and a large number passing overhead (flocks of several hundreds are commonly reported in winter throughout the northwest, including Uttar Pradesh — Ali & Ripley 1969) could esily lead to a misrepresentation of their actual numbers. At best, the Narayanpur report must be labeled hypothetical.

Some extent of the ecological changes wrought in this part of India over the last 100 years can be understood by comparing Hume's 1868 account of the area, later British gazateers of Etawah and Mainpuri districts (Neave 1910, Drake-Brockman 1911), and the results of this recent survey. When Hume served as district magistrate of the Etawah District, the northeastern portions of the district were a mixture of marshy lowlands and forests, the latter of considerable size and consisting primarily of *Butea frondosa* or Dhak, interspersed with cultivated lands. It was in the lowlands with their *matiyar* soils of dark, stiff clay that monsoon rains collected and formed numerous jheels; these in turn attracted huge numbers of wintering waterfowl, including Siberian Cranes. Over the next 40 years, civilization continued to encroach on this area, so that by the first decade of the 20th Century, the forest was nearly gone, the victim, perhaps, of Dhak's considerable commercial value for dye, *kino* (a gum used with indigo), various astringent medicines, rope, cauking, and other uses (Drake-Brockman 1911). More importantly, in 1877 the whole canal system of Etawah District, first introduced in 1855 with the construction of the Etawah Branch of the Ganges Canal, underwent extensive alteration. New channels or distributaries were cut through much of the district, and many jheels were either directly drained, or rain water was diverted from the natural channels, or *nadis*, that normally supplied many jheels, into surrounding fields for irrigation purposes. Improvements on the drainage system continued on into the next century, and the process goes on today.

The loss of the Dhak forests, coupled with better drainage, undoubtedly increased human activity in and around the once sequestered jheels, a result which would detrimentally affect the security of cranes and other wintering species. Today, many of these grand marshes that once teamed with wildlife are reduced to little more than muddy ponds, encircled by villages, and used incessantly for domestic and livestock purposes. Waterfowl that have the temerity to land on such ponds are targets for guns and nets. While these hunting activities are strictly illegal, the state government seems powerless or uninterested in halting them.

Most of the 48 jheels we surveyed, consequently, are completely uninhabitable for Siberian Cranes. Besides the human disturbance, few supported any emergent vegetation *Cyperus rotundus*, an important food plant for the Siberian Crane at Keoladeo National Park (Sauey 1979), forms large tubers that are also eaten by people and livestock, such as pigs (B. Khan, pers. comm.), thus perhaps accounting for its absence in 67% of the surveyed jheels. In other parts of India, the plant has a propensity to dominate Indian wetlands (Spitzer 1979). Still, the plant was found at 7 of the 48 jheels in good numbers, and presumably such places might support a flock of Siberian Cranes over winter, if they were unmolested.

Such speculation is not merely academic. During two recent winters, 1969-70 and 1979-80, Keoladeo National Park experienced a severe drought, and only a few Siberian Cranes appeared at the sanctuary (Savage 1970, Breeden & Breeden, unpublished manuscript). Where did the remainder of the flock winter those years? A strong possibility is that many continued farther east into the Gangetic Basin and spent the winter at whatever suitable jheels they could find. In a recent survey of the area, Singh et al. (this volume) found no cranes themselves (nor did most locals recognize the birds), but they did interview villagers at Kakwan [26.44N 79.58E] and Bahosi [26.55N 79.38E] who gave good descriptions of these cranes, and said that they saw them only once, during January and February, 1980, the winter of the last drought. Only a half dozen birds were seen at both locations, and a hunter at Kakwan reportedly trapped or shot one individual because of its unfamiliarity. If these reports are accurate, it is probable that these cranes were part of the Keoladeo flock and were forced into this unfamiliar area because of the drought.

Thus, even if Siberian Cranes no longer winter anywhere in India besides Keoladeo National Park, a need still exists for safeguarding wetlands in areas where the birds are most likely to seek refuge during droughts, such as the western portions of the Gangetic Basin. We don't want to minimize the magnitude of such an undertaking, especially since a large scale public education program would be required to conserve these birds successfully. But the stakes are high. Drought occurs with enough frequency at Keoladeo that the problem seems always imminent. Publicity regarding this crane, perhaps with a reward for positive identification of these birds, and a concurrent stiff penalty for their disturbance, should be disseminated throughout Uttar Pradesh. In such a manner, Siberian Cranes additional to those that winter at Keoladeo may also be located, if indeed they exist. Distribution of flyers or pamphlets might be possible through irrigation officials or other government agents. The International Crane Foundation would be willing to develop such education material with the cooperation of interested parties in India.

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DISCOVERY OF THE NESTING GROUND OF THE OB RIVER POPULATION OF THE SIBERIAN CRANE

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The first factual evidence of Siberian Cranes (*Grus leucogeranus*) nesting on the lower reaches of the Ob River dates from 1979, when a citizen of the town of Gorki in Shuryshkar District of Tiumen Region, T.P. Soldatova, sent to the Oka Reserve's rare crane center a year-old bird, taken as a downy chick somewhere in the vicinity of this town.

In May-June 1981, an expedition from the National Research Institute on Nature Conservation and Reserves of the USSR Ministry of Agriculture and from the Oka Reserve conducted special searches for Siberian Crane nesting areas in the north of Western Siberia. Using an AN-2 airplane and occasionally an MI-8 helicopter we surveyed the territory from the shore of Baidarat Inlet in the north to the town of Berezovo and the Kazym River in the south, and from the upper reaches of the Synya River in the west to Lake Numto and the middle reaches of the Polui River in the east (*Fig. 1*). Over about 40 hours, we flew routes totaling more than 6,000km. On the basis of the literature and anecdotal data we had already determined the most promising places, and these we carefully studied from 100m altitude. Most of the aerial survey was made when cranes can best be seen: after the bogs are free of snow and before the leaves come out on trees and shrubs. Because of late snow-melt due to a cold spring in 1981, flights near Berezovo could not begin earlier than June 10, and near Salekhard, only a week later.

On 14 June, on the right bank of the Ob, on the lower reaches of the Kunovat, five Siberian Crane pairs were discovered; we could see that two of them had eggs in their nests (one egg in one, two in the other). All pairs were on the periphery of a wide boggy area (about 200km^2) covered with lakes in the midst of northern taiga larch forest. The distance between the closest nests in this unique "group" settlement was 1.5km, and between the most distant was 10km. Between 16-25 June, we found three more isolated pairs, occupying smaller raised bogs in larch forests north of the Kunovat. Also, two lone birds were sighted on the south side of the Pitlyar bog (*Fig. 1*).

After examining the nesting biotope we turned our attention to the surrounding landscape. The most interesting in this regard was the section of the right bank of the Ob that encompasses the basin of the Kunovat River and extends north to the Pitlyar River. A search for Siberian Cranes in the flood plain between the Greater Ob and Lesser Ob was fruitless, although most of the word-of-mouth information about Siberian Cranes comes from this area. The reason could be the unusually high level of the spring floodwaters in 1981. It is not impossible that in better years Siberian Cranes also settle in this flood plain, on islands between flooded meadows with long narrow stands of willow, in conditions reminiscent of the open and flat nesting habitat of the eastern population in Yakutia.

Of eight territorial pairs that we discovered, five were definitely nesting, which was

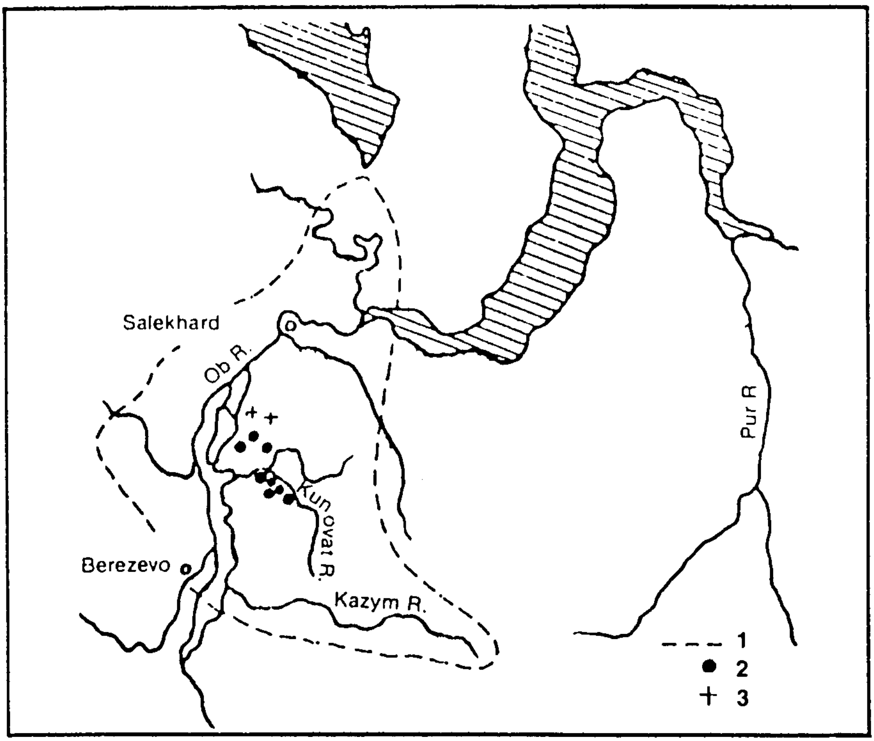

Fig. 1. Siberian Crane Nesting Area on the Lower Ob River. 1 - boundary of the territory surveyed; 2 - nesting or territorial pair of Siberian Cranes; 3 - lone cranes.

confirmed by their repeated presence. One pair was clearly not nesting; it was not determined whether the other two pairs were nesting or not.

The nests we inspected were placed on peaty, hollowed sphagnum bogs (quagmires as a rule) near the edge of stunted, frequently dead larch forest. They were built openly, on mounds between hollows or on low mossy peat banks with lone-growing, dwarfed larch trees and deformed, low birch, usually no farther than 1.5-2.0km from a large (up to 1km in diameter) lake. The cranes avoided both bogs with dense growth of trees and shrubs, and completely open, unvarying boggy areas.

Common Cranes (*Grus grus*) were found in the same habitat; four of their nests were discovered in the Siberian Crane settlement south of the Kunovat River described above. In two cases nests of the two species were within 1km of each other.

When an airplane approached, the Ob River Siberians reacted surprisingly differently from Yakut Siberians. They sat unusually tightly on their nests, tolerating the aircraft flying at the lowest possible altitude. When frightened, they almost never flew, but instead tried to hide under a tree, and very quickly returned to their nests. The Common Cranes behaved similarly.

On 25 June from three Siberian Crane nests we took one egg each for the crane center at Oka Reserve. A check on one of the nests after 24 hours showed that the birds were continuing to incubate the remaining egg. On the day of egg collection, one nest contained a half-hatched chick, and two other pairs' behavior indicated that they already had hatchlings. If one calculates backwards according to a 30 day incubation period, then egg laying would have taken place in the last week of May. At this time the snow had only just begun to melt (daytime temperatures consistently rose above freezing only in the last third of the month), and in the nesting region the first thawed areas on the higher elements of the microrelief had just begun to appear. In just such places, on high moss hummocks between hollows, there were two large nests many years old. A third structure examined in detail was newly built, judging by the thinness of the lining of the cup, which probably meant that the birds could not get to their accustomed nesting place at the proper time. Similar situations have been recorded in Yakutia in years when spring is late.

CHAPTER III

EDITORS' INTRODUCTION: COMMON CRANE

The Common Crane has an enormous range: from Spain and North Africa to eastern Siberia, and from the Asian tundra to the upper reaches of the Nile River in Africa. It is one of the most abundant of all cranes, undoubtedly numbering in the hundreds of thousands. Its success can be attributed to its ability to nest in a diversity of wetland habitats, its cryptic coloration and shyness, and its habit of foraging in agricultural fields.

Common Cranes do, however, have limits. They were extirpated as breeding residents in England during medieval times. Cranes last nested in Hungary in 1892, and have not been observed breeding in Spain since 1952-54. Following World War II the numbers of breeding pairs declined in northeastern Europe, although stringent protection in recent years has resulted in a strong recovery of their numbers. In contrast, Soviet biologists indicate that modern agricultural practices are driving the cranes from their former nesting habitats. The USSR population is becoming increasingly fragmented, although the Common Crane is by no means endangered in that country.

A Working Group on Common Cranes under the leadership of Dr. Joost Van Der Ven (State Forestry, Nature Conservation Department, P.O. Box 20020, 3502 La Utrecht, Netherlands) was formed at the International Crane Workshop and subsequently met in Hungary in 1985 to develop plans for a complete census of the Common Cranes in Europe in 1988-89.

A leader in crane research and conservation, Dr. Wolfgang Makatsch participated in the International Crane Workshop and shared his findings concerning the cranes in East Germany. Unfortunately Dr. Makastch passed away soon after the Workshop. He will always be remembered by his many scientific publications and, in particular, a classic in crane literature, *Der Kraniche*, published in 1970.

THE COMMON CRANE IN SWEDEN DISTRIBUTION, NUMERICAL STATUS, HABITATS, BREEDING SUCCESS AND NEED OF PROTECTION

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ABSTRACT

Ten years ago the Scandinavian population of the Common Crane was estimated to be between 24,000 and 48,000 individuals (Alerstam & Bauer 1973). The majority of these cranes breed on wetlands in the coniferous woodland of northern Sweden. A few thousand individuals nest in Norway and the remaining cranes breed in wetlands of southern and central Sweden.

In 1980 the Swedish Ornithological Society performed a country wide census of the cranes. The results were acceptable only for that part of the country south of the provinces of Värmland, Dalarna and Hälsingland. In this area the population was estimated to be 1300 breeding pairs, which indicates an increase in the last three decades. Probably this increase is due to crane use of new types of breeding habitat. Formerly the cranes were located in undisturbed wetlands in the forests far away from human settlements. Today the cranes breed at lakes, small marshes and other wetlands, often near human villages and activities.

During 1977-1982, 81 breeding results were monitored in the province of Gastrickland in central Sweden. All together 40 fledglings have been produced for a mean of 0.5 fledgling per pair, a rate that renders the Common Crane a successful species in this part of Sweden.

In 1927, the cranes were protected by Swedish law against hunting and egg collecting during the breeding period. Since 1969 they have been protected throughout the year. At the moment it does not seem necessary for additional conservation activities in the breeding areas. Yet it is still important to minimize disturbances at resting and roosting places during migration and on wintering grounds.

INTRODUCTION

The crane family is represented in Sweden by two species. The Common Crane (*Grus grus*) nests regularly in nearly all parts of the country, and the Demoiselle Crane (*Anthropoides virgo*) has been encountered on seven occasions in May-July between 1857 and 1977. In addition, there is one report of a Siberian Crane (*Grus leucogeranus*) in southern Sweden early in the spring of 1931, obviously a speciman escaped from captivity. Probably this is true also for some of the Demoiselles, especially two tame birds seen in northern Sweden in the spring of 1977.

Swanberg has surveyed the Common Crane (1981). Studies of the species have focussed on migration and the occurrence at resting and roosting sites, especially Lake Hornborgasjön in the province of Västergötland. Reports on the breeding biology are

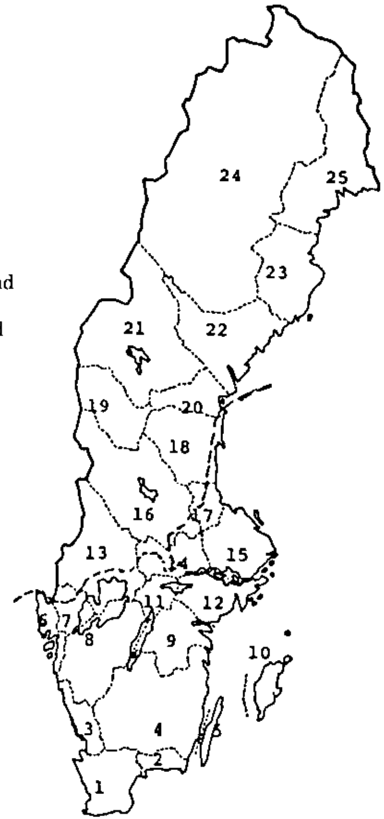

Fig. 1. The provinces of Sweden.

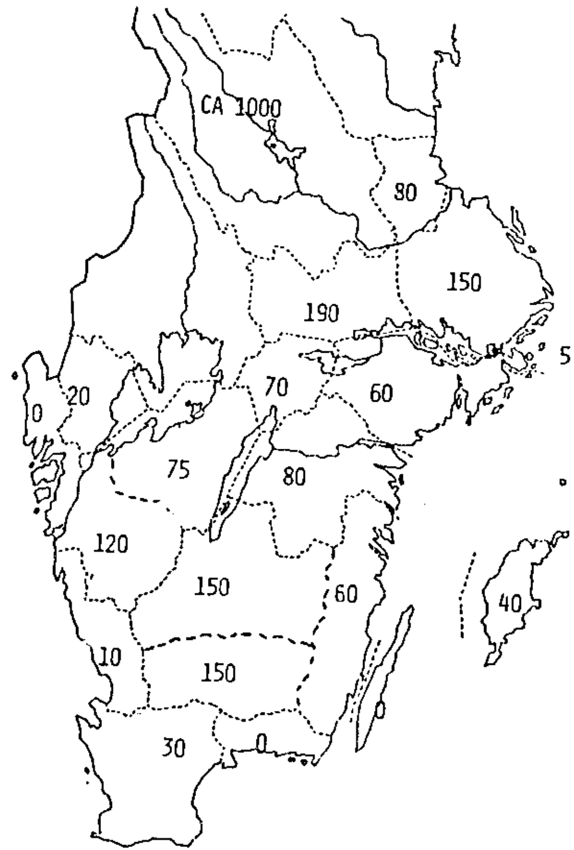

Fig. 2. The number of breeding pairs in different provinces of south Sweden

scarce and detailed information about the distribution and numerical status in different provinces is lacking.

In this paper new data are presented about the status and breeding biology of the Common Crane in Sweden. Most of the information has been obtained from a census of the breeding cranes performed by members of the Swedish Ornithological Society in 1980, and from the author's studies of the cranes in the province of Gastrikland in central Sweden during the last decade (*Fig. 1 and 2*).

DISTRIBUTION

The Common Crane has a long history in Sweden. Probably it invaded the Scandinavian peninsula from the east shortly after the latest glacial period, about ten thousand years ago (Løppenthin 1967). Of course, we do not know much about its distribution and numerical status during this time, but it is possible that it soon became an abundant nesting bird all over the country and that it maintained this status up to historical times. The first scientific reports on the Common Crane tell us that it was breeding in the southern part of Skåne, the southernmost province of Sweden, in the beginning of the nineteenth century, but that it later disappeared from this area, as well as from some other southerly Swedish provinces. In the beginning of the twentieth century, it was absent from Skåne, Blekinge, Halland, Dalsland, Öland, and Gotland. The two latter provinces are both islands in the Baltic Sea and it is not proved that the Common Crane has nested in these areas until the last decades.

Obviously, this decline of the crane population in southern Sweden is paralleled by corresponding decreases in other West European countries, e.g. Great Britain, Holland, Denmark, and especially the German Federal Republic. The main causes of the decline seem to be disturbances from the expanding human population and activities, including drainage of important wetlands and, to some extent, hunting.

Nowadays, this situation has changed. During the last two decades, the Common Crane has begun to increase in southern Sweden. The first nesting record in Skåne in recent time was made in 1965, in Halland and Dalsland in 1975 and on the island of Gotland in 1958. Still the species is absent from the provinces of Blekinge, Bohuslän and Öland, but apart from these areas it is distributed all over the country. It is most abundant on marshes and at lake margins in the large coniferous forests in northern Sweden, from Värmland, Dalarna, and Hälsingland. Northwestwards its distribution area is limited by the Scandinavian mountain chain, which in northern Sweden reaches about 2000m.

In this area, the status of the Common Crane is not sufficiently known, but in general it is considered to breed in the subalpine birch region. In the earlier literature there are also a few reports of cranes nesting on the alpine heaths above the tree limit, at an altitude of about 1000m.

NUMERICAL STATUS

As Swanberg (1981) noted, the Scandinavian population has been estimated twice before. In 1968, Swanberg found it to be "more than 10,000 cranes," based on the study of the cranes gathered at Hornborgasjön and a simultaneous inquiry in the mass media.

This conclusion was confirmed to be correct in 1972, when Alerstam and Bauer (1973) made a radar study of the crane migration in the southern Baltic area. In all, they recorded about 1200 radar echoes during the migration period, each corresponding to a crane flock. The mean flock size was estimated at 20-40 individuals; based on this, the total Scandinavian population was calculated as 24,000-48,000.

This conclusion presupposes that all the Scandinavian cranes return to Sweden through the Southern Baltic area. But as *Fig. 3* shows, the long distance recoveries of young Common Cranes banded in Sweden suggest that the northernmost population has another route. This question needs further research.

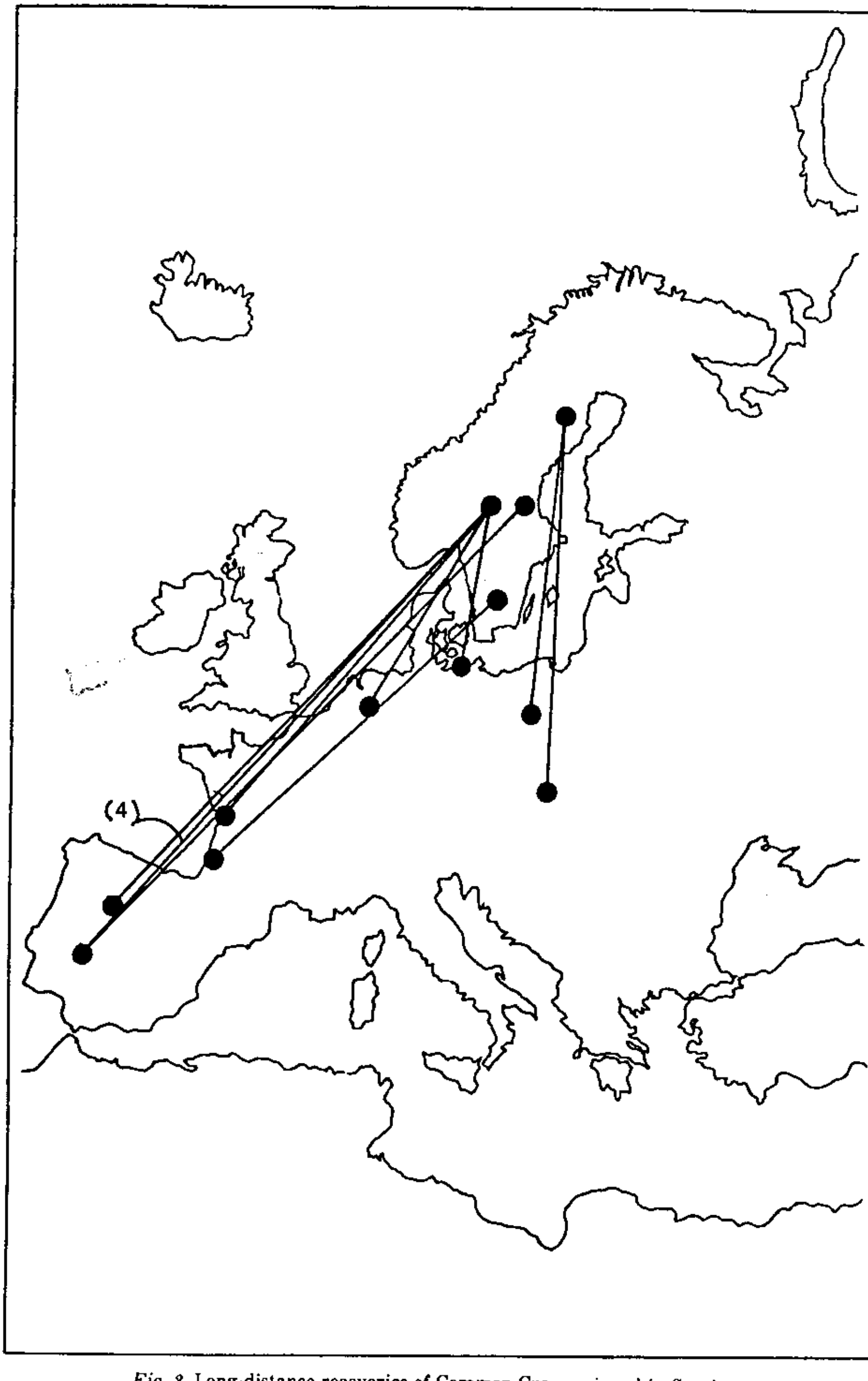

Fig. 3. Long-distance recoveries of Common Cranes ringed in Sweden.

In 1980 the members of the Swedish Ornithological Society performed a country wide census of the breeding cranes. The census method used was discrete visits to possible nesting sites during the incubation period in late April and May. The so-called "possible" nesting sites were chosen from the Swedish topographical map. It separates wetlands of different degrees of humidity. Wetlands with a high water level are blue-lined and drier marshes, such as peat bogs, are brown-lined. Cranes prefer to lay their eggs surrounded by water and therefore they almost always prefer "blue" wetlands to "brown." A special and abundant kind of blue-lined wetlands is the margins of vegetation rich lakes.

In an earlier work (Bylin 1980), the author has shown that the efficacy of this method is about 90%. At least this seems to be true in central and southern Sweden, where the potential breeding localities are rather small, comparably easy to reach by ground and easy to observe. In general, each locality has a single breeding pair, but sometimes a larger area holds two or three territories.

It is possible to increase this efficacy by using some other methods, e.g. aerial surveys. In central Sweden about half the expected number of crane sites can be found by circling a few times above them at an altitude of about 100m. From an aeroplane, the grey Common Cranes seem very light when in flight, but when they are standing on the ground they are very difficult to discover.

In northern Sweden, north of the zoogeographical border called "limes norrlandicus," which runs through the southern parts of Värmland, Dalarna and Gästrikland, none of these methods are very suitable. Here, in the westernmost part of the Siberian coniferous taiga, the marshes often are too large and remote to be covered from the ground or to make aerial surveys efficient. Probably the best technique should be extrapolation from smaller, well studied plots in different habitats and different subregions, but such studies have not been performed. In fact, two other important circumstances influence the census work this area: the cranes are very numerous and the ornithologists are very few. Therefore the census results in this part of the country are too incomplete to be discussed in this paper.

Fig. 2 shows the estimated number of breeding pairs in all provinces south of the "limes norrlandicus" and, in addition, in Dalarna just north of this limit. In all, about 1300 pairs were found in these southern provinces, which is interesting to compare with the census result in Dalarna. In this northern province alone, rich in forests, lakes, and marshes, the crane population was calculated by different methods at 1000-1300 pairs. Still, this is a small part of the 24,000-48,000 individuals counted by Alerstam and Bauer (1973), which gives an idea of the numerical status of the Common Crane in northern Sweden. The Norwegian part of the total Scandinavian crane population is in general considered to be rather small (Haftorn 1971).

The most interesting and pleasant news obtained by the census was the status of the Common Crane in some of the southernmost provinces. As already mentioned, the cranes were absent from large areas in this part of the country during the first half of the twentieth century, but in the last two decades they have returned and are now nesting in increasing numbers. The following table shows the time of the reestablishment (or in some cases the first establishment) and the recent status in some of these provinces:

Area	First breeding record in recent time	Recent status (pairs)
Gotland	1958	40
Skåne	1965	30
Halland	1973	10
Dalsland	1973	20

It is the opinion of the author that the Common Crane has increased in number also in most of the other provinces in south and central Sweden, but this is not possible to prove because the status of the species in these areas was not known before 1980.

HABITATS

The explanation for the increase in Common Cranes in southern Sweden is very important and interesting, especially from an ecological and conservation point of view. In the last two or three decades, the Common Crane has broadened its acceptance of different habitats.

In earlier literature the crane is described as an extremely shy species, very hard to approach or study at its nesting sites. It was considered to breed on desolate marshes in large forests, far away from human settlements and activities, exactly as the cranes still do in northern Sweden, north of the "limes norrlandicus."

In the latter area, the landscape is characterized by mountains and valleys, large coniferous forests, oligotrophic lakes, mountain slopes, and many other wetlands, especially large bogs and swampy forests. The majority of the numerous breeding cranes will seldom be disturbed by human activities, though the area is subject to intensive forestry. The mean population density ranges from 10 to 1 inhabitants per km^2; most areas are far from human settlements. The smaller roads built for forestry are often closed to the public.

South of "limes norrlandicus," the terrain is somewhat different. The earth is more fertile and suitable to agriculture and, therefore, large areas are cultivated and characterized by fields, grassland, grazing cattle, eutrophic lakes, and a more decidous woods. The coniferous forests are smaller than in northern Sweden, and the same is true for the wetlands. It is in this part of the country that most of Sweden's 8 million people live. Of course it is obvious that a bird with all the characteristics ascribed to the Common Crane by early Swedish ornithologists should be rare in such surroundings.

However, in the last decades things have changed. Nowadays the cranes are not reduced to the habitats described above. They have begun to nest at eutrophic, vegetation rich lakes, small marshes, and other wetlands in agricultural areas, often surprisingly near human villages and activities. The nests are often built in sedge (*Carex* sp.) on a ground of reedmace (*Typha latifolia*) or even in reedbeds (*Phragmites communis*) far away from the shore. In fact, sometimes the nest of the crane looks like the nest of the Mute Swan (*Cygnus olor*), an abundant species in Swedish eutrophic lakes. The cranes use this habitat as nesting, resting, roosting, and, to some extent, foraging sites, especially when the young are small. In general, to forage, the pair, the family, or the nonincubating mate has to visit cultivated fields or, if possible, peat bogs or other open wetlands near the nesting territory.

The evolution of this new ecological tolerance has taken place not only in the southernmost provinces but also in several other areas in south and central Sweden, where the species always has been abundant or at least present. In central Sweden, the author recognized this change in the late 1960s. Within a few years, several crane pairs began to nest in agricultural districts where no breeding cranes had been seen before. Probably all the pairs were young birds, as they occupied the new territory at least one summer before they tried to nest.

The combination of a nesting and a feeding territory in agricultural areas seems to be good for the cranes and their reproduction. In Gastrikland almost every such locality is occupied by cranes. In one case, three pairs live close together at a small, vegetation rich lake with an open area of 25ha, situated about 200m from the nearest farm house. The three pairs fly to forage in different directions. In addition, the total population of the province also includes several young pairs, which still have not found a suitable breeding locality, and often visit the established pairs in the vicinity.

BREEDING SUCCESS

The breeding success of the Common Crane in Sweden has been studied in two different areas. The author (Bylin 1980) has published a preliminary survey of the breeding results of 37 different pairs in Gästrikland, observed in connection with a census of the Common Crane in this province in 1977-79. In 1978-80, a comparable study was conducted by Nilsson (1981) in the county of Kronoberg, a part of the province of Småland in southern Sweden, where 37 breeding pairs were monitored. Since then, the author has continued the work in Gästrikland, and now data on 81 breeding attempts are available from this province, some of them referring to the same pairs in different years.

The study method used was similar in both areas. Known nesting localities were visited in late summer to count fledged young. This is best done at sunset, when the family returns to the nesting site to roost. However, sometimes you have to visit the same locality several evenings before you sight the cranes. At localities difficult to observe because of shrubs or tall aquatic vegetation, it often is possible to find the cranes, especially the male, by playing a tape recording of the unison call.

A survey of the known breeding results in Gästrikland in 1977-82 is shown in *Table 1.* Each breeding pair has produced a mean of 0.5 fledgling, with a variation from 0.2 to 0.85. The corresponding mean result in Småland was 1.0 young per pair; this difference has been discussed by Nilsson (1982). He suggests that it is due to the population being nearer the carrying capacity of the habitats in Gästrikland compared to Småland. The population densities are, respectively, 1.5 and 1.7 pairs per 100km^2 total area (including lakes) in the two regions, but the amount of fen area is larger in the latter region. The changes in numerical status and habitats mentioned above seem to confirm this hypothesis.

Another difference between the two study areas is the proportion of pairs that fail to produce fledglings and those that rear one or two young. In Småland, only 32% of the clutches were lost and 32% of the pairs succeeded in rearing two young. The corresponding result in Gästrikland is listed in *Table 2.* On average only 10% of the pairs were observed with two fledglings and 59% had lost all their eggs or young. These figures correspond extremely well to Swanberg's (1977) observations on the island of Öland during the autumn migration. He found that only 25% of the crane families with young consisted of two young.

Table 1. Breeding success of the Common Crane in the province of Gastrikland, central Sweden, in 1977-1982.

Year	No. of Pair Studied	No. of Fledglings	No. of Fledglings Per Pair
1977	15	3	0.2
1978	10	4	0.4
1979	15	11	0.7
1980	13	11	0.85
1981	14	5	0.35
1982	14	7	0.5
TOTAL	81	41	0.5

NEED FOR PROTECTION

The Common Crane is not a threatened species in Sweden. As described above, the population has increased in southern Sweden during the last two decades and probably it is still increasing. The trend in the central and northern parts of the country is not sufficiently known, but there are no signs of a decrease. In fact, the species seems to be successful even in these areas.

The main threat in the future will probably be the drainage and exploitation of wetlands for forestry and other purposes such as peat extraction. However, in general the bogs suitable to such projects are suboptimal as crane habitats, and probably only a lesser part

Table 2. Breeding success in the Common Crane in the province of Gästrikland, central Sweden, in 1977-1982.

	Number of Fledglings			
	0	1	2	
Year	Number of Pairs			Total
1977	12	3	0	15
1978	7	2	1	10
1979	6	7	2	15
1980	6	3	4	13
1981	9	5	0	14
1982	8	5	1	14
Total	48	25	8	81
Total %	59%	31%	10%	

of the Swedish crane population will have their territories destroyed. Yet the Common Crane is listed by Swedish authorities and nature conservationists as a species which is to be taken in special consideration.

In 1927, the Common Crane was given protection during the breeding season by Swedish law, and since 1968 this protection is in force throughout the year. In general, the species also seems to be well tolerated by farmers and other land owners, and by all other people. On the other hand, during the autumn migration the cranes still are disturbed at the roosting sites by duck hunters. The hunting often starts late in the evenings, when the cranes have landed. They become frightened by the shooting, take off, and become scattered in the darkness. Probably it often happens that young cranes become separated from their parents during these flights. The same problem occurs when the hunting starts early in the mornings.

Let us hope that all important resting and roosting localities of the Common Crane will become nature reserves in the near future, not only in Sweden but also along the entire flyways and in the wintering areas.

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MIGRATING COMMON CRANE IN SWEDEN: EXPERIMENTS IN FARMING FOR CRANES AND VEGETATION CONTROL IN WETLANDS

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ABSTRACT

Experimental management techniques at Lake Hornborga, southern Sweden, have demonstrated how easily large numbers of Common Cranes (*Grus grus*) may be attracted to a staging area they had previously abandoned. Fields planted with potatoes and scattered with barley draw as many as 2760 cranes per day in spring. Restoring water to Lake Hornborga, which in the first part of the twentieth century had become a marsh, has made the lake extremely attractive to cranes from mid-August to mid-October. At least 3000 feed and rest there. Restoration of water has also made the lake suitable for nesting by cranes; 5-7 pairs now breed there.

The Common Crane (*Grus grus*) is by no means an endangered species. However, it has suffered a marked decrease in southern and western Europe. As late as in 1954, it still bred in southern Spain. Nowadays, the population in Europe is restricted to the northern and eastern part of the continent, indicating that it needs protection of habitats as well as protection from shooting in wintering areas.

The importance of ecological factors is demonstrated by the behaviour of the bird in southern Sweden. When migrating in spring from its winter quarters in Spain and Morocco, the Scandinavian population of the Common Crane has for about 100 years had its largest and most regular Scandinavian staging area at Lake Hornborga, today more of a marsh, in southern Sweden. To the south, the nearest major staging area is in the German Democratic Republic on the southern border of the Baltic, where cranes wait for suitable flying weather with thermals. Sometimes they may stay there for weeks, awaiting appropriate weather conditions. From this point south of the Baltic Sea, a flight to Hornborga is about 500km, a nonstop flight in fine weather or a two day trip, if the birds meet bad weather on their way north. When, in the beginning or middle of April, they leave the coastal area south of the Baltic, they encounter a more northern climate: the vegetation has scarcely begun to grow, lower animal life may be dormant, sometimes the ground may be snowcovered. At Hornborga, however, there has been for about 100 years a reliable, good supply of food, in the form of potatoes left in the ground after the preceding year's harvest. By freezing in the winter these potatoes acquire a high sugar content which is of great nutritional value.

Until 1971 the extensive and concentrated potato growing was required by two big distilleries. When the distilleries closed, the large scale potato growing ceased in 1972, and in the following years the cranes found that the attractive and reliable food source had disappeared. As a consequence, the number of birds gradually decreased and was very low in 1979.

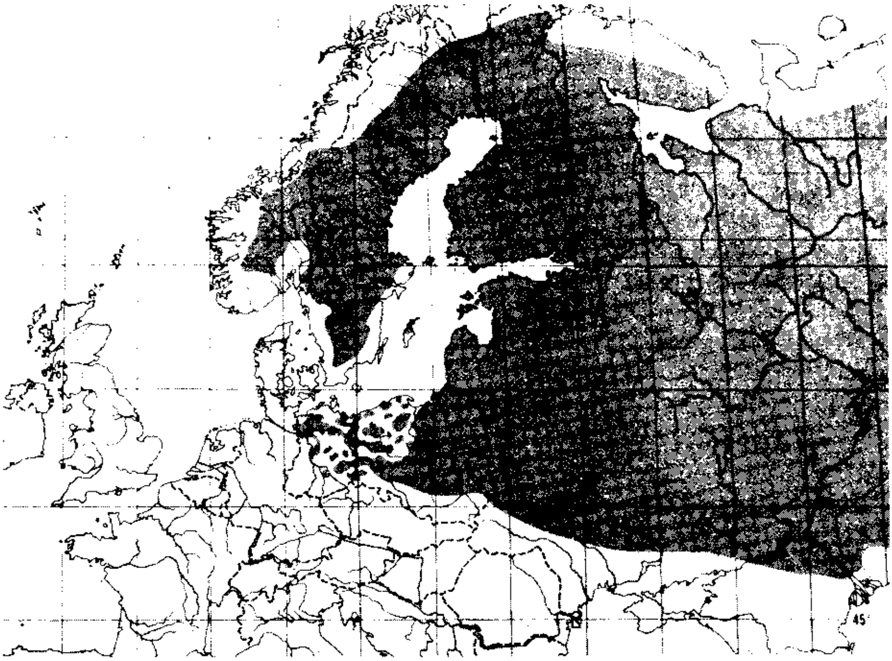

Fig. 1. Distribution of breeding common crane, *Grus grus*, in Europe west of 50°, E Greenwich. (From S. Cramp 1980. Handbook of the Birds of Europe, vol. 2.)

Fig. 2. A crane probing for winter-frozen potato in a last year's potato field, 18th April 1974, at Lake Hornborga.

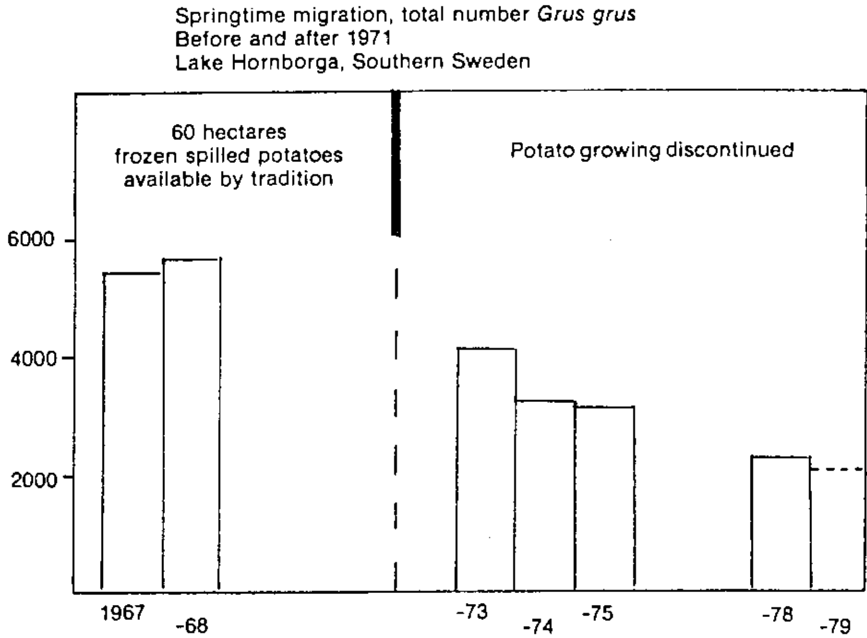

Fig. 3. Springtime migration of the common crane at Lake Hornborga, Southern Sweden. Total number resting cranes before and after 1971.

EXPERIMENTS TO ATTRACT CRANES

For some years after 1971 it was impossible to reestablish conventional potato growing, not even for the cranes, at this staging area. We tried new, experimental ways of feeding them. At first we bought potatoes, had them frozen, and carried them to traditional fields, where older cranes had learned to find potatoes. When cranes did find such potatoes, they accepted them, but these potatoes, however, were not as attractive as the spilled ones that had been left over the winter in the soil and had to be dug out by the birds themselves. The deficiency in this way of supporting the birds was, in our opinion, that the cranes usually were not able to identify fields. We concluded that the cranes are, by experience, so well aware of the normal picture of a harvested potato field with the characteristic remaining dry stems left on the surface, that they did not expect attractive food on uncultivated ground without such stems.

In other experiments, barley was spread on fields where the cranes could be expected. The migrating cranes, however, for the most part failed to find the fields and the grain. Since we knew that fields of barley, which because of bad weather have not been harvested and have then been covered with snow all winter, are a marked attraction for cranes, we once tried to raise barley and other cereals, leaving them unharvested. In practice this did not work: when the fields were not covered with snow all winter, thousands of other birds consumed all the food before arrival of the cranes.

After some unsuccessful experiments with artificial feeding, in 1980 we had the opportunity to raise potatoes in a field specially for cranes. Cultivation was done in the conventional manner, but the potatoes were left in the soil. Since we knew that barley is still better as food, barley was spread on the potato field to increase its attractiveness. The cranes soon discovered the improvements, and the number of cranes in the fields increased from a maximum of 750 in one day in 1979 to 2760 in one day three years later. In that year, 1982, they were supplied with 5.2ha of potatoes and 10 tons of barley. As the number of so-called "crane-days" in April that year was 18,500, each crane, on an average, had been supplied with 3 square metres of potato field and 500 grams of barley per day.

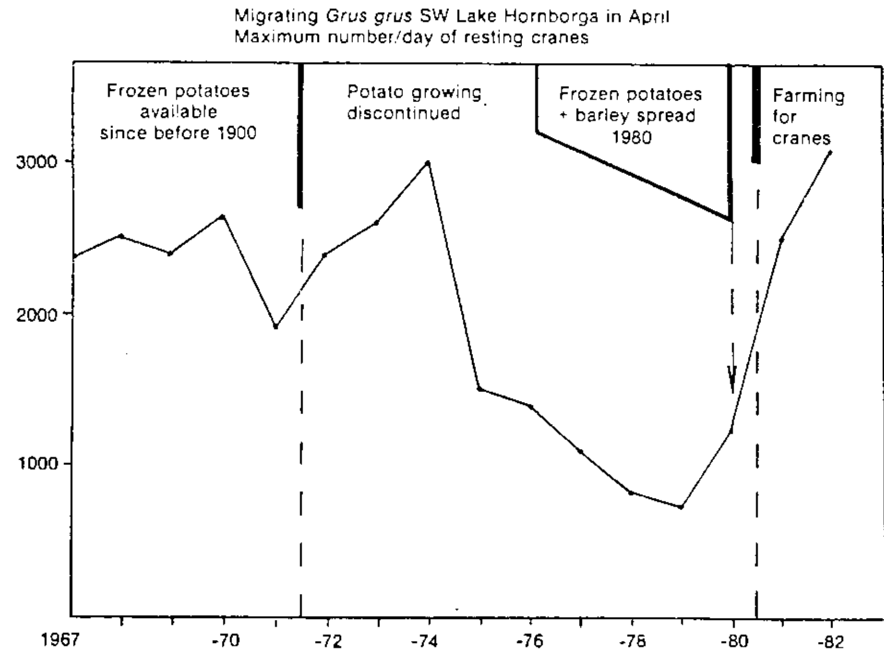

Fig. 4. Migrating *Grus grus* SW Lake Hornborga in April. Maximum number/day of resting cranes.

This spectacular congregation of large, beautiful birds attracts many tourists and bird watchers. The successful result of the experiments has encouraged the authorities to continue growing potatoes, which the birds have to pick out by themselves. In 1983, the area farmed for the cranes was increased from 5 to 9ha.

EFFECT OF VEGETATION CONTROL

Fifty years ago Lake Hornborga was drained and transformed into a marsh covered by dense reeds. In autumn, there were few areas of open shallow water. Until 15 years ago, no cranes stopped at the marsh in autumn. They flew over at considerable height and few were observed. In the years 1963-1970, a restoration of the former lake was planned, with an opening in the 25 sq km reedbed, giving 1.5 sq km of open water, which in the autumn is only 5-10cm deep. The cranes soon found this shallow water good for roosting; they were already regular visitors in spring. With that the lake was established as a valuable staging area in the autumn migration as well, and the number of cranes increased from none three decades ago to at least 3000 in 1982.

Cranes now visit Lake Hornborga from before mid-August to mid-October, demonstrating that the lake has become attractive because it provides a good roosting site in a good feeding area. It also shows that the opportunity for a long stay in this northern district, only a few days' flight from the more northerly, cold breeding areas, is evidently of great importance for the birds at the time when the young are newly fledged and the birds have to build up a lipid reserve before their long migration south. This conclusion is

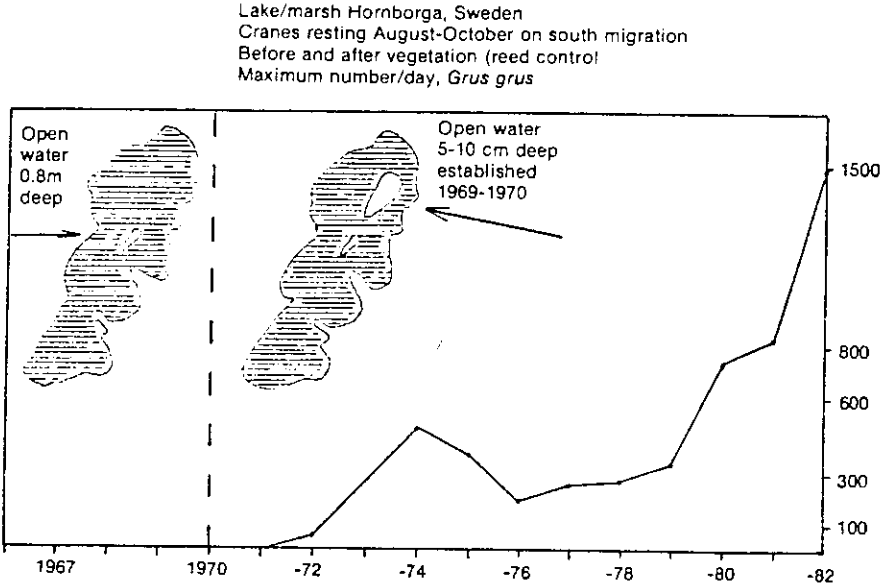

Fig. 5. Lake/marsh Hornborga, Sweden. Common cranes, *Grus grus*, resting August-October on south migration, before and after vegetation (reed) control. Maximum number/day.

supported by observations 2500km further south, on the island of Cyprus in the eastern Mediterranean. Many thousands of cranes from eastern Europe stop there, Common Cranes as well as many hundreds of Demoiselles. They arrive in the evening, roost overnight, and after sunrise, during the 2-3 hours before their departure for Egypt, do not search for food. Other thousands of Common Cranes do not land at all; they fly on to Egypt during the night in a nonstop flight. They may cover 800km, perhaps considerably more. In contrast to the situation in northern Europe at the beginning of the migration, they have no need for long resting and feeding stops later when crossing the Mediterranean, 2500km south of Hornborga.

This shows, too, the importance of maintenance and protection of the chain of wetlands listed in the Ramsar Convention, that aims to make wetlands secure for bird migrations crossing the European continent.

Finally, it may be worth mentioning, that although 13 years ago no cranes nested in the marsh, after vegetation control, 5-7 pairs breed there. Perhaps we have, in northern Europe, a reserve population of birds ready to occupy newly established, suitable habitats in proper geographical districts.

THE COMMON CRANE IN POLAND

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ABSTRACT

The paper describes the occurrence of the Common Crane in Poland. No strong human pressure against this species was found to exist. It was estimated that today approximately 600 pairs nest in Poland. Three routes of intensive migration through Poland were distinguished. No decrease in number of cranes in Poland is observed. The number can be kept at the present level if the areas of the cranes natural environment are preserved in sufficient number and properly protected.

The Common Crane (*Grus grus*) is found throughout Poland, though it is nowhere common. This is presumably due to its ecological requirements; it nests in remote and inaccessible marshes and swamps, usually in dense forest areas. Cultivated land is frequently used for feeding. Cranes avoid close contact with people. Due to their expansive territorial requirements, preferred areas are usually occupied by single pairs.

Thus, its distribution may be compared to that of some birds of prey, and can be described as "common, but not frequent" (Dobrowolski 1963). Cranes can be found in most environmentally appropriate areas, but never in large numbers.

Poland also lies on the crane's migration route. Migrating cranes stop in areas never used for nesting. Big flocks quite often feed in fields. Autumnal migration overlaps in time with the post breeding roving season of the Polish nesting population.

A nineteenth century book on Polish birds (Taczanowski 1882) says of cranes, "its meat is black and hard, worse as food even than that of wild geese."; it also states that cranes nest in dispersed pairs, in small numbers, and in rather few places, mainly east of the Vistula river. There was probably never any strong hunting pressure on the crane in Poland. In the 1920s and 1930s a certain drop in the number of cranes was observed. There was, correspondently, a decrease in recorded nestings. This decrease, however, soon stopped, and already in the 1950s and 1960s a certain growth of the number of cranes in Poland occurred (Tomiałojć 1975).

Although in Poland the crane was never exposed to strong hunting pressure , or caught by country people, in 1952 it was given legal protection. Killing, catching and keeping the birds, and destroying nests, eggs, or nestlings are legal offenses and a cause for punishment. Due to this, in Poland the crane has only natural enemies, such as carnivorous mammals and birds of prey.

It seems, however, that this kind of protection will not increase the number of cranes, as they were never exposed to a serious menace from men. Much more important is preservation of natural nesting areas by creating national parks and protected areas or reservations, and this has been done in Poland.

Information on the number and distribution of cranes in Poland, was gathered in 1982 from state nature conservers. These are state officials dealing with problems of nature protection, operating in the 49 districts (called voivodships), into which Poland is divided. Data were collected by sending questionnaires. Answers came from 45 districts. In 3 of the missing 4 districts, cranes are not likely to occur, according to published data (Bochenski 1960, Bochenski & Harmata 1962, Dyrcz 1965).

The material received is thus sufficient to determine the status of the crane in Poland. The questionnaire asked the following questions: distribution of nesting localities (stating whether the information is confirmed or supposed); numbers in flocks on migration; changes in number of cranes in the area.

Comparative analysis of the responses poses certain problems. First, answers from different districts may vary in accuracy, according to the respondents' different training. We may suppose that, in general, numbers are rather underestimated, especially those from the northeastern region. Secondly, the ornithological survey of Poland is quite insufficient in some regions; there are areas from where no literature information can be found, which also makes it harder to confirm and compare the material.

Bearing this in mind, we can admit, however, that the data obtained are sufficient to prove the following statements:

1. Overall, the number of cranes nesting in Poland can be estimated at about 600 pairs. They are distributed mainly in the western and northern parts of the country (*Fig. 1*). This corresponds rather closely with the distribution of larger marsh areas in Poland (*Fig. 2*). In the areas where intensive draining and amelioration of agricultural land took place in recent years, a correlated decrease in number of cranes is observed. More interesting, however, is the fact that today the crane is more common in the western part of Poland than it was earlier in this century or in the nineteenth century. These districts have for a long time been highly agricultural and have few large forests. This suggests cranes can adapt to some changes that man introduces in the environment.

2. The spring migration through Poland has already been investigated and was accurately described by Sierakowski, Pinowski, and Wolański (1969). No important changes are likely to have occurred since that time. A distinct route leading from south to north through the eastern part of Poland can be traced. Another route, much less intensively used, leads from west to east through the northern lake districts. In the remaining areas, migration is much less intense (*Fig. 3*).

As the spring migrations have already been the subject of research, we considered it worthwhile to put more attention on the autumnal flights. Autumnal migration of cranes in Poland begins in September and lasts through October and November. The information that we obtained covers the entire period. The flocks recorded include not only the birds actually migrating through Poland, but also of those nesting in Poland, that at the time wander extensively (*Fig. 4*). It appears that the areas where migrating birds congregate generally correspond with nesting areas. This seems to be due to a preference in both cases for a similar environment.

Some flocks of migrants, however, were recorded in places where no or little nesting is observed, especially in the northwestern part of the country. These were most probably migrating flocks feeding on fields.

Generally speaking, autumnal migration differs distinctly from the spring one. Although a similar eastern route from north to south and a northern route from east to west exist, there is also a third route, not occurring in spring, that leads from north to south through the western part of Poland. It is possible that Scandinavian birds take the western route, going south through the Moravian Gate pass and Czechoslovakia, while northwestern populations choose the eastern route towards the Dniestr river. A certain

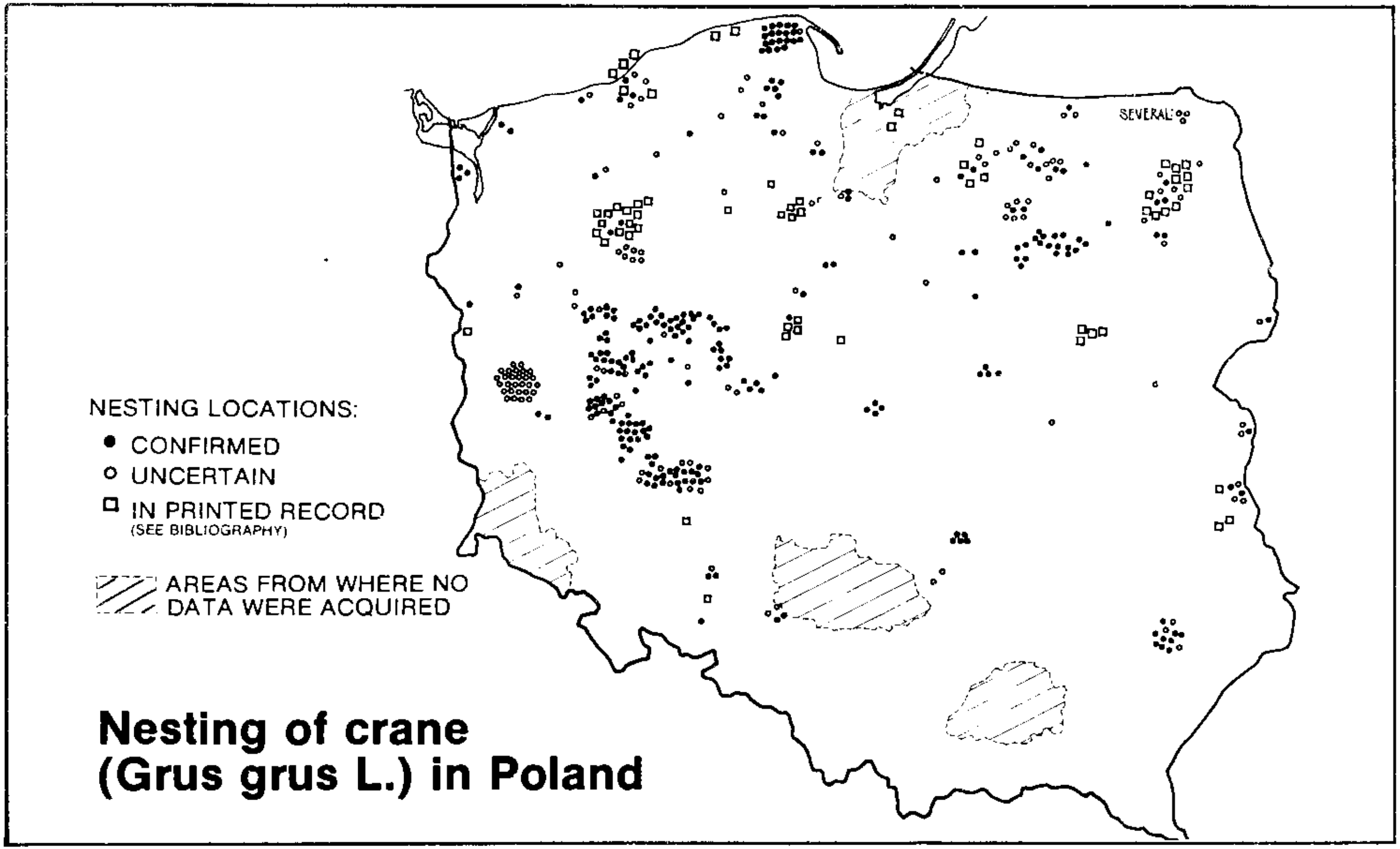

Fig. 1. Nesting of crane (*Grus grus* L.) in Poland.

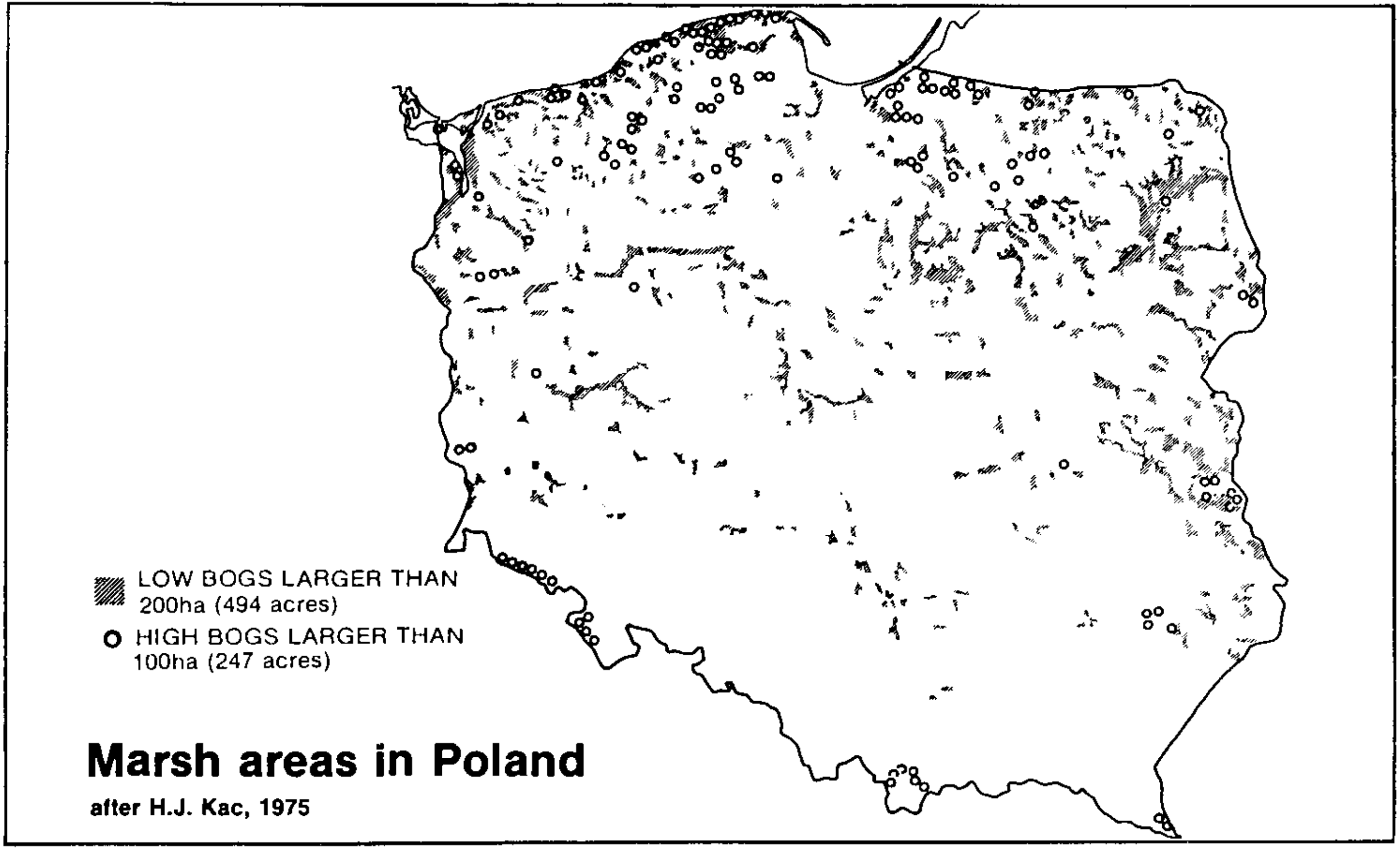

Fig. 2. Marsh areas in Poland.

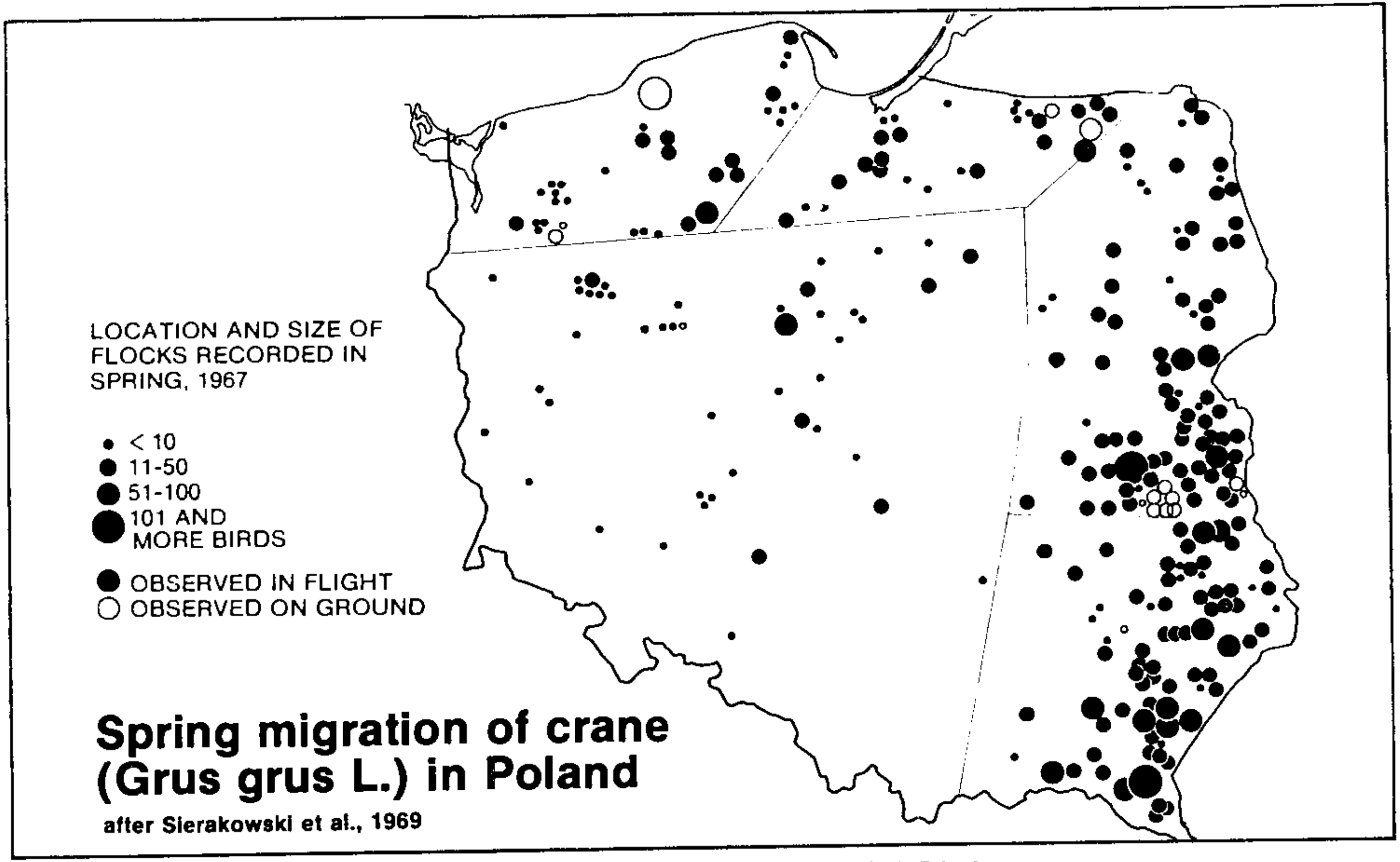

Fig. 3. Spring migration of crane (*Grus grus* L.) in Poland.

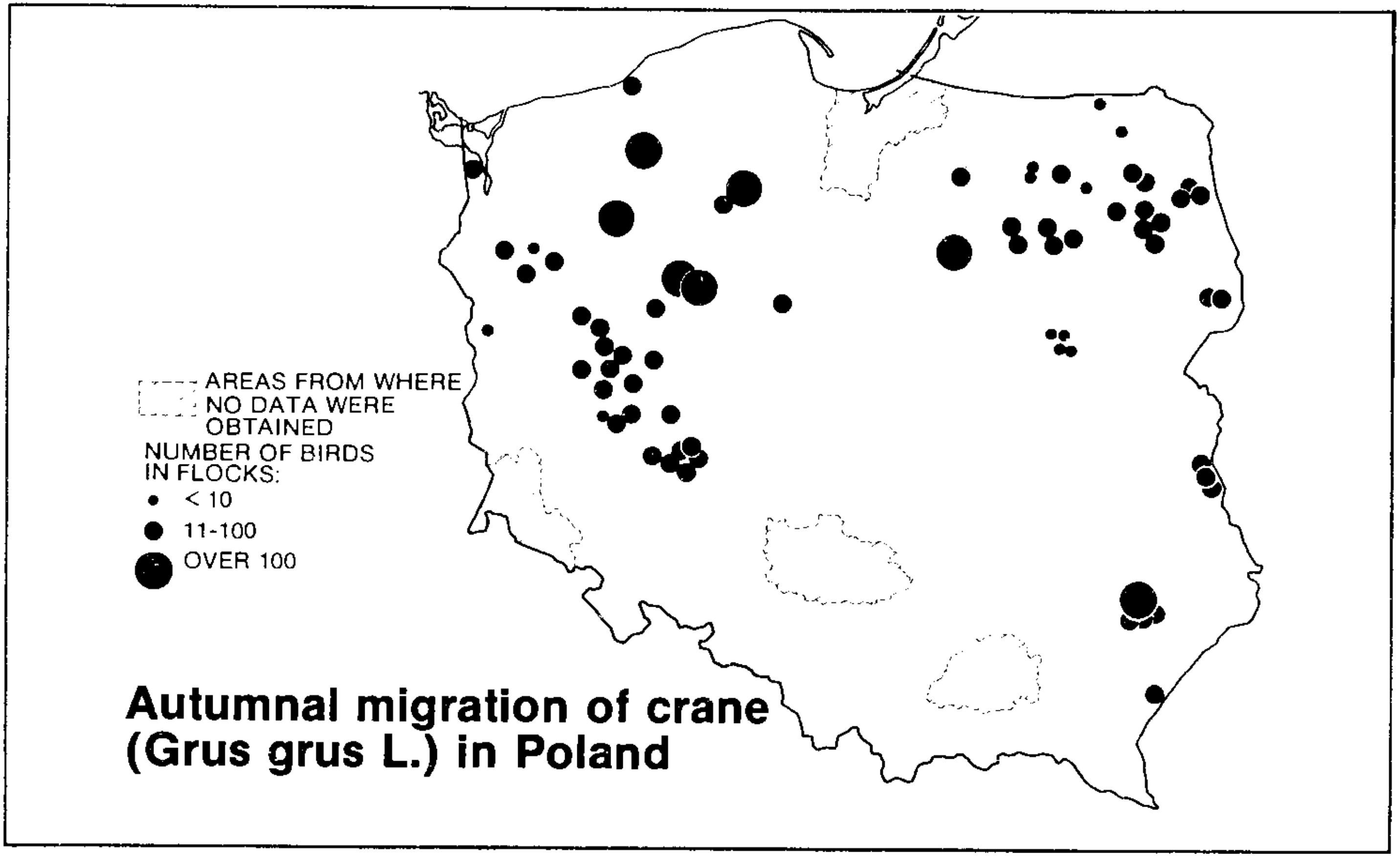

Fig. 4. Autumnal migration of crane (*Grus grus* L.) in Poland.

part of both populations probably takes the northern path through the Polish lake districts and migrate west.

In conclusion, it can be stated that:

1. No decrease in the total number of cranes nesting in Poland has been observed. Some drop in number has been recorded in northwestern districts (presumably due to drainage carried on in the area), while in the districts west of the Vistula River a certain increase has occurred.

2. The Common Crane is under a total legal protection. Keeping its population on a steady level will depend on creating an appropriate number of reservations to protect its natural environment.

3. During autumnal migration three intensive routes can be distinguished; eastern and western routes from north to south, and the northern route from east to west.

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THE STATUS OF THE COMMON CRANE IN THE GERMAN DEMOCRATIC REPUBLIC

WOLFGANG MAKATSCH

ABSTRACT

The population of Common Cranes (*Grus grus*) in the German Democratic Republic today numbers approximately 500 breeding pairs. The birds are particularly vulnerable to management of ponds for fish production, which destroys the marshy vegetation on which the birds depend. Common Cranes are found throughout the country, but are most numerous in Mecklenburg, which has 360 breeding pairs.

DISTRIBUTION

The German Democratic Republic (GDR) is situated at the farthest western fringe of the immensely large breeding territory of the Common Crane (*Grus grus*), which extends from Scandinavia and central Europe through Eastern Europe and central Asia eastwards to the upper course of the Indigirka, possibly even to the upper course of the Kolyma. The nesting sites in the GDR lie mostly in Mecklenburg, Brandenburg, as well as in Lower and Upper Lausitz. The total crane population of the GDR today may be 500 pairs.

The majority of cranes breeding in the GDR are found in Mecklenburg and Brandenburg, i.e. the districts Schwerin and Neubrandenburg, as well as the northern parts of the districts of Potsdam and Frankfurt-Oder, which are no longer part of Mecklenburg. To the south, in Lower and Upper Sausitz, in the districts of Cottbus and Dresden, the number of cranes is remarkably less, and westward to the Elbe only a few nesting sites are known.

In Mecklenburg the cranes are unevenly spread; most of them are found around the lake district of Mecklenburg, extending in northwest-southeasterly direction right through the region Schwerin and the south of Brandenburg. The smallest crane population is in the coastal area, in the district of Rostock. To the south are numerous breeding areas in the north of the Potsdam region. To the west, the breeding habitat reaches to the lower and middle Elbe, i.e. to the western parts of the districts of Schwerin and Magdeburg. West of the river Elbe, there are only a few single nesting areas in the districts of Magdeburg and Leipzig, as well as in the adjoining areas of the German Federal Republic (Schleswig-Holstein and Niedersachsen).

In Mecklenburg, the total crane population probably numbers about 360 nesting pairs, of which 14 pairs reside in the district of Rostock, 130 pairs in the district of Schwerin and 218 pairs in Neubrandenburg. The remaining 140 pairs — assuming a breeding population of about 500 pairs for the whole of the GDR — live in the other regions. The three districts of Brandenburg-Magdeburg, Potsdam, and Frankfurt-Oder, might hold about 120 pairs, or possibly even 150.

Taking a line from Magdeburg via Berlin to Frankfurt-Oder, then to the south of it, the crane in southern Potsdam as well as in the districts Cottbus and Dresden are widespread, but not as frequent a nesting bird as in the northern districts of the GDR. Here the nesting places are situated mostly in Lower Lausitz and to the south in adjoining Upper Lausitz. West of the river Elbe, there is only one breeding spot, which has been occupied for many years, in the Wildenhainer Bruch east of Leipzig. This was the breeding habitat of 4 pairs in 1971, and probably still is today. In the region of Magdeburg, especially in the vicinity of the castle and in the area of Genthin, there were 12 pairs in 1970.

ECOLOGY

While in Mecklenburg and Brandenburg the crane breeds in the moors and valleys, in the transition zones of lakes and ponds, in alder brush, and wooded moors of the beech and pine woods. In Upper Lausitz it prefers the transition zones of ponds. I found most of the nest sites in this biotope. In northern Lausitz are numerous ponds, mostly man-made. In 1950 the total surface area of these ponds in the Kamenz and Bautzen districts was 4500ha. Improvements and the new dredging have added another 500ha. Adding the Hoyerswerda, Weisswasser, and Niesky districts, the surface area of ponds in Upper Lausitz is about 10,000ha. These ponds even today are partly surrounded by a reed zone and a plant-rich transition zone with a water depth of 30 to 100cm. There are also larger and smaller moors, and swampy, reed-covered meadows in the midst of pine woods. These reed areas in shallow water and the transition zone of the pond edges are the preferred nesting areas of the cranes in Upper Lausitz. Only a few pairs breed in open moors and in the smaller wooded moors. Two pairs nested in swampy fields; these two nest sites, however, have not existed for many years.

The most favourable years for the 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.

Altogether I have had 27 pairs under survey after World War II in Upper Lausitz. Unfortunately, I was not able to carry out the surveys every year. It is quite possible that some nest sites were occupied 10 years and more by the same crane pair. Cranes stick with great tenacity to their nest sites as long as these are not destroyed by human interference. A few examples: One pair bred from 1947 to 1951 in a pond near Hermsdorf/Spree, another one from 1948 to 1952 near Lippitsch, a third pair 1951 to 1959 near Spreer Heidehaus, a fourth pair from 1953 to 1963 near Dauban, finally a fifth pair from 1962 to 1972, again near Spreer Heidehaus.

POPULATION

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 Lausitz. Fortunately, the population decline has halted and numbers seem to be stable. In recent years, the number of cranes has slightly increased in Upper Lausitz, and some old nest sites which had been abandoned years ago, were again reoccupied. So it is to be hoped that the present crane population of about 20 breeding pairs will remain stable in the future.

But what are the reasons for the decline in the crane numbers in Upper Lausitz and other regions? At fault in the decline of our crane population in recent years is the governmental pond management program 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 huge 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 only the cranes — are deprived of their breeding sites for all time. Other affected species, for example, include *Podiceps cristatus*, *Podiceps griseigena*, *Botaurus stellaris*, *Anser anser*, and *Circus aeruginosus*.

In Mecklenburg, the circumstances are more favourable, since there we have mostly natural lakes and not man made ponds used intensively for fish cultivation. Klafs and Stübs (1977) report that in some places breeding sites fall victim to pond management but that in other areas a decline is not likely.

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 lignite mines in the middle of this pond region in the Upper Lausitz. This mining also permanently destroyed nest sites. The ponds dried out completely and were abandoned by the cranes. It is very difficult, if not impossible, to determine whether these cranes moved to other areas in Upper Lausitz.

It is often said and written that the Common Crane is an endangered species. It would be more correct to describe our crane as "threatened with extirpation." The expression "endangered species" used so frequently may be correct for other crane species, but is not quite fitting for the Common Crane, the population of which amounts in the GDR alone to about 500 pairs. There can be added thousands of breeding pairs in Scandinavia, Poland, and the Soviet Union. If the number of cranes should decrease, then 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. The Common Crane is not endangered in its entire breeding territory. And when nowadays year after year in spring and fall 20,000 to 30,000 cranes migrate through middle Europe, then this should be proof enough that fortunately our crane is not yet threatened with extinction. Also, we should not forget that the breeding area of our crane lies in middle Europe at the southwestern periphery of its range. We know also from other species that, especially in such fringe zones, population fluctuations are rather frequent.

However, that should not prevent us from doing everything we can do to save the small population of nesting pairs in highly populated central Europe. But such preservation is possible only if we maintain the breeding biotope — that is, the transitional areas on pond edges, the moors, and the swampy meadows — in their present condition.

Agriculture and pisciculture 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 about 500 breeding pairs will remain in the coming years in the German Democratic Republic.

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BREEDING STATUS OF THE COMMON CRANE IN THE FEDERAL REPUBLIC OF GERMANY

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ABSTRACT

Since 1972, the number of Common Cranes (*Grus grus*) breeding in the Federal Republic of Germany has increased from 16 to 24 pairs. Productivity has risen from .5 to 1.13 per breeding pair. Nesting habits and distribution are described.

INTRODUCTION

As far as known, the Common Crane (*Grus grus*) has never been a common breeding bird in the Federal Repuhlic of Germany. In 1900, the maximum population appears not to have exceeded 50 pairs; by 1950 there were about 35 and in 1972, following thorough surveys, only 16 pairs. The main breeding area has always been the northeastern part of West Germany, in the federal States of Schleswig-Holstein and Lower Saxony, and was always closely connected to the more densely populated area of East Germany (GDR). There are indications that around 1850 single pairs existed in Bavaria, probably part of the population then existing in Austria and Hungary, that became extinct a few years later. In the north of Germany, there was up to 1949 one breeding place near the border of Denmark. These birds probably were associated with two or three breeding pairs in Denmark that possibly belonged to a former population in the south of Scandinavia.

In 1972 the World Wildlife Fund began a program of scientific research and practical conservation work on the Common Crane. Among the measures taken on behalf of the crane are maintaining appropriate water levels at nesting sites, acquiring feeding areas, protecting the cranes from enemies such as wild boars that have increased recently, and guarding nests. Following are some of the data that has enabled the Fund to draw up a conservation programme for this species.

NESTING PLACES

In West Germany the Common Crane nests in a variety of habitats. About 20% of breeding pairs use reed beds of shallow lakes, where the nests are made of plants (*Phragmites, Typha, Carex*). Sixty percent nest in swampy woodlands; here the birds often don't build nests, but simply lay their eggs on tree roots, especially those of *Alnus glutinosa*. The remaining 20% inhabit peat bogs, building the nest on sphagnum. A decisive factor in the choice of nesting site is the water level; it must provide a vantage point and protection against predators approaching from land. Nests are usually surrounded by water of a depth of 50cm.

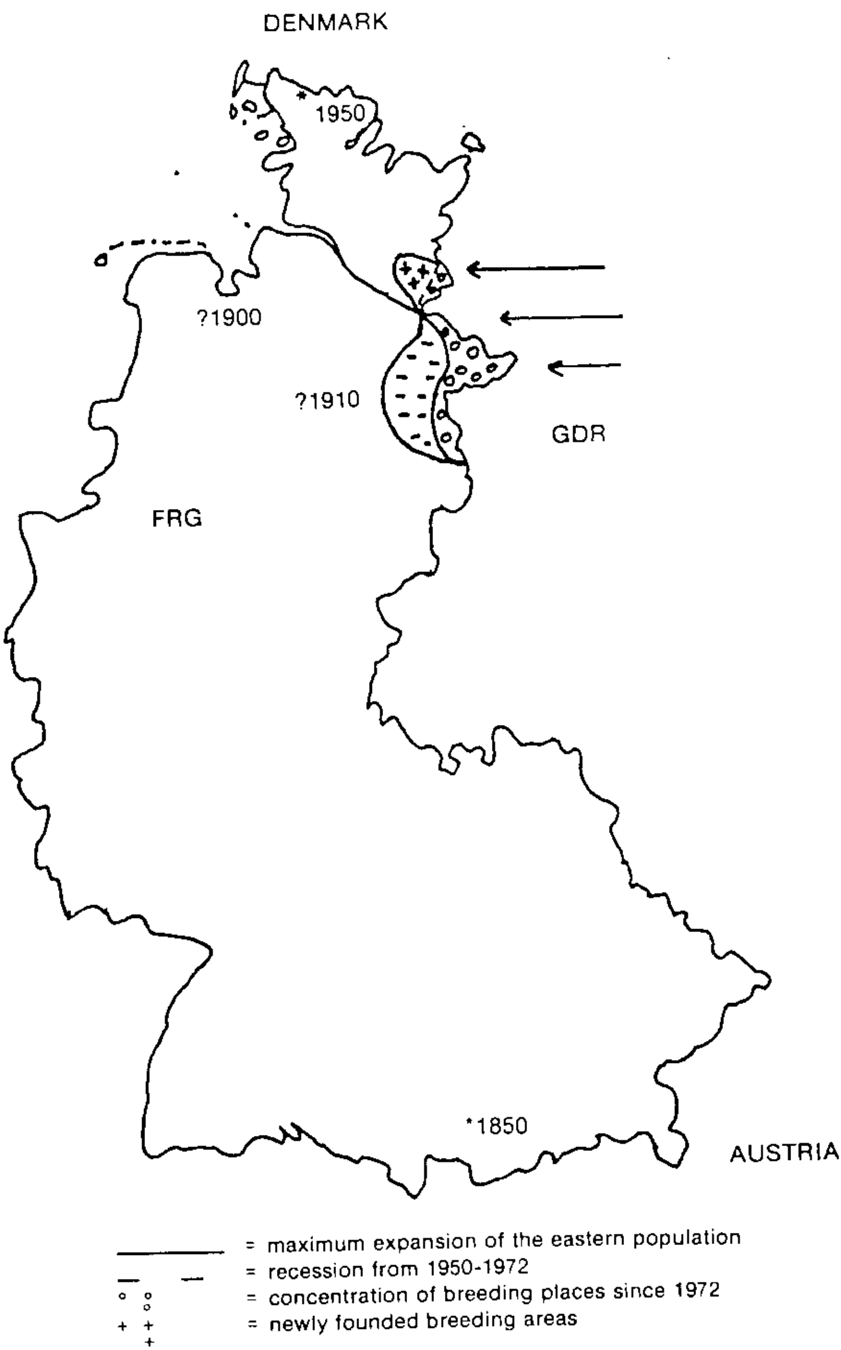

Fig. 1. Distribution of the Common Crane in the Federal Republic of Germany.

Eggs are sometimes laid at the end of March; the earliest recorded was on 21 March on frozen swampland. One assumes that disturbed clutches (broken eggs) are often due to spring frosts. Cranes are able to lay a second clutch, normally also consisting of two eggs, and even a third, consisting of only one egg.

REARING THE YOUNG

Crane families often undertake extensive walks when rearing young. The availability of animal food, particularly insects, seems to play a decisive role in the first 6 weeks of the young bird's life. During observation of a pair of cranes breeding in a peat bog, it was noted that the birds wandered up to 5km from their nest with the nestlings. Another pair breeds regularly and successfully on an island only .02km^2 large surrounded by a deep lake.

Breeding success depends mainly on availability of food and on weather conditions at hatching time. Early broods, which hatch at the end of April, are rarely successful, as few sources of plant or animal food have developed. In addition, if nesting and feeding places are separated by roads, chemically treated agricultural land, etc., many nestlings don't survive.

HABITS OF CRANES AFTER THE BREEDING SEASON

Towards the end of the rearing period, crane families move to arable land, and feed on crops, particularly maize and potatoes. This has led, doubtlessly, to the fact that staging areas during migration are varied and also that the time of fall migration is delayed. On 22 December 1982, for example, 90 cranes were seen on arable land in Schleswig-Holstein. These arable areas, however, also have disadvantages for cranes: they are more accessible, and human interference is difficult to prevent, resulting in the birds being driven into the air more often than is normal for them. Not only do they lose energy reserves in this way, but also are in danger of flying into electrical telegraph wires. Of 17 adult birds found dead in 1975-1982, 8 were certain deaths by electrocution.

Table 1. The development of the crane population since 1972.

Year	Pairs	Breeding pairs	Fledged Young Birds	% Per Breeding Pair
1972	17	16	8	0.50
1976	20	16	18	1.13
1979	27	22	19	0.86
1980	27	23	25	1.09
1981	28	25	30	1.20
1982	27	24	27	1.13

The population increase started slowly after 1972, but the number of fledged young birds per breeding pair seems to be relatively high.

Cranes are moving back into former breeding areas, and into new areas. In Schleswig-Holstein, the population has spread 30km further west, into areas where cranes have never been known to exist.

By using the crane as a symbol of nature conservation, it has been possible to protect wetlands for other endangered animals and plants as well.

THE MIGRATION OF THE COMMON CRANE IN HUNGARY DURING 1982

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ABSTRACT

Based on migration data during spring and autumn, the passage of Common Cranes (*Grus grus*) over Hungary is analyzed in relation to weather conditions. In the Kardoskút Nature Reserve, the most important staging area, the maximum number observed in spring and autumn was 3000 and 15,000, respectively. The autumn figure is the greatest number seen in several decades.

THE MIGRATION PATTERN IN RECENT DECADES

The route taken by the majority of cranes crossing Hungary extends across the eastern border of the country parallel with the flow of the river Tisza, over the territory east of the river Tisza. Smaller numbers travel between the river Danube and the river Tisza and over Trans-danubia.

The most important staging areas in the territory east of the river Tisza are located at the Hortobágy, in the vicinity of Biharugra and at Kardoskút, as well as at some neighbouring sites to the south (Tótkomlós, Békéssámson and Pitvaros). The Pusztaszer Reserve, between the Danube and the river Tisza, and Kelemen-szék and Zab-szék, in the Kiskúnsag National Park, are the most important resting places.

Prior to the intense development of the nature reserves, no suitable conditions existed in the plain for undisturbed roosting sites. The autumn migration coincided with the peak season of waterfowl hunting. No area surrounded by puszta was without hunting activity in the evening. This dispersed the crane flocks and probably speeded their passage through Hungary.

The Kardoskút Nature Reserve, initiated by István Sterbetz, was established in 1966. Now, it is the most important gathering and resting place for the cranes in the Carpathian basin. The intense protection and the hunting prohibition have resulted in a significant increase in the number of cranes using this site. Its importance has not been reduced by the establishment in 1970 of the other protected areas in the Trans-Tisza country. Large scale corn production offers excellent feeding sites. The quantities of maize crops remaining on the field after combine harvesting provides a basic foodstuff for the cranes for weeks, and sometimes for months.

Table 1. Quantitative variations in the migration of cranes (*Grus grus*) in the Kardoskút Nature Reserve, between 1966 and 1982.

Year	Spring maximum (specimen)	Autumn maximum (specimen)	No. of residence days	
			spring	autumn
1966	2500	1020	25	46
1967	300	508	31	49
1968	800	1260	22	45
1969	1200	2000	27	61
1970	800	2500	19	64
1971	600	1800	23	69
1972	550	1500	30	71
1973	600	1800	23	68
1974	4000	14000	36	75
1975	3000	5000	39	79
1976	4000	10000	31	73
1977	4000	10000	33	70
1978	5000	3000	34	65
1979	2000	8000	36	88
1980	4500	4000	41	83
1981	3000	6500	42	66
1982	3000	15000	36	92

The importance of the Kardoskút Nature Reserve in relation to crane migration is demonstrated by *Table 1.* It is clear from the table, that the number of cranes using Kardoskút has followed a fluctuating but a gradually increasing course during 1966-1982. Low and high figures during the spring migration were 300 in 1967 and 5000 in 1978. Corresponding figures for the autumn migration were 508 in 1967 and 15,000 in 1982. The number of days when cranes were present also increased, with a range of 19 to 42 days in spring and 45 to 92 days during autumn. It can be also seen from the table that spring migration took place more rapidly and with fewer birds landing than in autumn.

The Kardoskút Nature Reserve and surroundings provide the best conditions for migrating cranes. The roosting site is a centrally located pond, 3km long, used both when at normal water level or when drying. The cranes feed in areas up to 25 to 30km away in a mosaic of natural grassy areas and cultivated fields. They drink at the narrow and dense canal system on the agricultural land (Sterbetz, pers. comm.).

In the vicinity of Kardoskút, the basic foodstuff for the crane is maize. In addition, winter cereal crops, various steppe grasses, and the soft green leaves of rape are important. Insects, weed seeds, and small mammals also enrich the diet (Sterbetz, pers. comm.).

THE 1982 MIGRATION

Spring Migration

The winter of 1981-82 was colder than usual. The daily average temperature 5-30 January remained below 0°C and there was only a thin snow cover on the plain. February was similarly cold; the average temperature was over 0°C only after 23 February. Therefore, cranes did not overwinter that year.

According to the Kardoskut records (Farkas, pers. comm.), the spring migration started on 1 March with the arrival of 21 birds. By 7 March, their number increased to 280 and on 9 March there were 1000-1200. The number of roosting cranes peaked at 3000, 18-20 March. On 25 March, there were only 1000 in the area and 5 April, the last crane left.

At the Hortobágy National Park the passage of approximately 2200 was observed by Gábor Kovács on 6 April.

In the Hortobágy district, four cranes were regularly observed during June and July.

Autumn Migration

The autumn of 1982 was an unusual one for crane migration. Record figures were recorded at several sites east of the river Tisza. At the peak of the migration, 1000 cranes stopped at Pusztaszer, between the river Danube and the river Tisza.

At Kardoskút, the first flock of 22 specimens appeared on 1 October. About 1300 arrived on 8 October, followed by an additional 9000-10,000 on 20 October. The next day 15,000 cranes landed at lake Fehér-tó at Kardoskút. Their number remained unchanged to 28 October, but then began to decrease. On 2 November, 13,000 and on 4 November only 10,000 were counted by István Stérbetz and János Farkas, followed by an abrupt decrease to 4000 by 6 November. From mid-November 3000 remained, until at least January 1983. This overwintering was probably due to the unusually mild winter.

Besides the Kardoskút area, unusual numbers of cranes appeared at other suitable sites east of the river Tisza.

On 18 and 19 October, for example, János Sára saw a continual passage at Dombrád, north of the river Tisza, of flocks of 80 to 100 flying south.

István Finta observed many in the Hortobágy National Park. On 24 October, 246 landed at Nagyhalastó and by the evening of 28 October another 600. On 31 October, 1200 cranes landed at the Nagykecskés puszta. On 3 November, a flock of 1200 arrived here from the northeast and landed at one of the ponds in the Nagyhalastó lakes.

Gábor Kovács also saw considerable crane numbers in the southern part of the Hortobagy. On 20 October around 145 appeared at Tilalmas, and on 21 October around 85 arrived at Kunmadaras, followed by 158 22 October. Another 600 were recorded at Borzas on 28 October.

On 3 November, István Sterbetz saw approximately 3000 in the district of Békéssámson and Pitvaros.

It is interesting, that this intense migration has had no visible signs in the western two thirds of the country. In the Kiskunsag National Park, at Kelemen-szek, where around 300 cranes used to appear during the autumn migration, only 9 landed, on 13 November (Bankovics, unpubl.). In spite of the conspicuousness of migrant cranes, their passage was evidently concentrated east of the river Tisza, where, compared with previous years, cranes appeared in greater numbers.

AGE DISTRIBUTION

Compared with the data for previous years, the percentage of birds-of-the-year proved to be surprisingly high. On 6 November there appeared at Kardoskut a flock of 25 birds, including 17 juveniles and 8 adults, and another group of 32 with 18 juveniles and 14 adults. The average percentage of juveniles in the total population proved, however, to be much lower. Based on the evaluations of István Sterbetz for 22 flocks between 1-4 November, the percentage of juveniles varied between 10 to 25%

COMPARISON OF THE SPRING AND AUTUMN MIGRATION OF THE CRANE TO THE WEATHER

The spring in 1982 was dry and cooler than usual. The summer was dry and warm, without cool weather. A similarly mild summer in northern Europe may have contributed to the high fledging success observed in Hungary.

In 1982, the cranes arrived at Kardoskút on 1 March, when the daily average temperature was 1.5°C. During their long stay here 1-24 March, the average temperature ranged from 1.5 to 5.9°C. On 24 March, a warming period began with an abrupt rise in the temperature to 10°C, and a gradual rise to 12°C by 29 March. The influence of this warming trend resulted in the gradual northern migration of the 3000 cranes concentrated at Kardoskút. The remaining birds stayed another week and the last left Kardoskút 5 April, when the daily average temperature had risen from 10 to 15°C. This warm spell initiated the migration of cranes in other places, as well.

During the autumn months, the weather was to be dry and warmer than usual. At Kardoskút, the first crane flock arrived from the north on 1 October, when the daily average temperature was 16°C. There was no significant change in the weather afterwards, the daily average temperature ranging from 15.8 to 10.9°C. The number of cranes slowly grew to 1300. On 14 October, there was, however, an abrupt drop in the average temperature. Probably this cold initiated the mass migration of the cranes that reached Hungary 18-19 October. At Kardoskút, their number increased to 10,000 by 20 October, and peaked with 15,000 on 22 October. After 31 October, the temperature initially decreased gradually but after 5 November fell abruptly. Parallel to the fall in temperature, the number of the cranes also decreased. At first it was a gradual decrease to 12,000, then, after 5 November, abruptly to 4000. The cooling was followed by milder weather with a daily average temperature of around 6°C that continued all winter. The 3000 cranes remaining by the middle of November remained in the area through the winter.

Weather, particularly the abrupt changes, may be an important factor in the crane's migration pattern. More definitive conclusions, however, require analysis of data from several years.

ACKNOWLEDGEMENTS

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THE SITUATION OF THE COMMON CRANE IN SPAIN

Crane Projects I and II: Migration and Wintering of the Common Crane In Spain during Autumn and Winter of 1979-1981

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CRANE PROJECT I PRESENT SITUATION OF THE COMMON CRANE IN THE IBERIAN PENINSULA

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ABSTRACT

A study is made of the wintering and migratory status of the Common Crane (*Grus grus*) in the Iberian Peninsula within the framework of Proyecto Grus I. Wintering takes place in groups of varying size and is centred on one large area which includes the provinces of Cáceres, Badajoz and Córdoba in Spain and the Alentejo in Portugal, with some marginal locations in Toledo, Avila, Ciudad Real, Huelva, Seville and Málaga. The Laguna de Gallocanta (Zaragoza), deserves special mention, having seen in recent years a marked increase in the number of birds present through winter and both migrations. Throughout the Autumn-Winter of 1979-80, 357 census-surveys were carried out, allowing us to affirm that the minimum number of birds wintering in the Iberian Peninsula is 15,000 to 16,000 individuals, distributed among 51-55 places, of which 20 were discovered during the present study. The spatial distribution of the places occupied allows us to establish two large areas in the Iberian Peninsula: the Eastern Side (Zargoza, Cuenca, Ciudad Real/Toledo), of great importance as the spring and autumn "collector" of more than 50% of the total of wintering birds; and the Western Side (Cáceres, Badajoz and Córdoba) where the main wintering quarters are sited. On this side the main body of cranes is distinguished from the peripheral zones, and the characteristics of each one are discussed.

Postnuptial migration is studied from the phenological point of view (end of September-end of November) and of the volume of birds involved, with the principal waves of migrants mapped out. Migration times are also analyzed, plus tendencies to group (average group size 50 individuals). Prenuptial migration is dealt with by the same means. We emphasize here the problem of confusion with *Anser anser*; the immense concentration in time and space in which this migration occurs (average size of groups is 107 birds) and the departure from the Iberian Peninsula centred on the province of Huesca, further to the east than the autumn arrival.

INTRODUCTION

The Common Crane (*Grus grus*) became extinct as a breeding bird in the Iberian Peninsula around 1952-1954 (Rowan & Bernis 1956). It is a regular wintering bird, especially in the southwestern part of the Peninsula. Being a vociferous and gregarious bird, its migration and wintering are well-known among country people, who have a wealth of popular sayings and refrains referring to it, almost always connected with the change of seasons and the agrarian tasks to be done. Thus the lack of recent scientific information on such an interesting bird is even more conspicuous; apart from the important general studies made by Bernis (1960, 1966) and the one carried out in Extremadura by Pérez Chiscano and Fernández-Cruz (1971), there are only scarce and fleeting references to the species in the Iberian bibliography.

This paucity of information, together with the agricultural transformations that have taken place during the last two decades over extensive areas of the west of the Peninsula (felling of great stretches of oakwoods, rapid change in crops, and other dangers inherent in urban and industrial development) and the fact that the species, like many others of large size, is decreasing in numbers, was the reason behind the planning of a joint study to be carried out with the following objectives: to determine the current population of cranes wintering in Spain (by extension, in the Iberian Peninsula); to discover and observe the main wintering quarters; to study migration movements across the Peninsula; and to investigate other eco-ethological aspects of the biology of the species.

MATERIAL AND METHODS

The study was carried out from the autumn of 1979 to the spring of 1980. General planning of field work can be seen in detail in Fernández-Cruz et al. (1981). Here we will deal only with wintering and migration. The working plan emphasized observation of known wintering areas and a search for new ones. It was carried out by a team of ornithologists from the Co-ordinating Federation for the Protection of Birds (CODA) and the Spanish Ornithologists Society (SEO).

Six national censuses were undertaken on the following dates:

General Census 1 : 17-18 Nov. 1979
General Census 2 : 15-16 Dec. 1979
General Census 3 : 29-30 Dec. 1979
General Census 4 : 12-13 Jan. 1980
General Census 5 : 8-10 Feb. 1980
General Census 6 : 1-2 Mar. 1980

The occupation of "pseudo-wintering" areas (Bernis 1960) required special attention on intermediate dates. A total of 357 census-surveys were carried out.

Observation campaigns of the autumn and spring migrations were made in the main known crossing areas (Pyrenees, Iberian System, Central System, New Castile, Lower Aragón and Pre-Pyrenees).

The most important part of this phase was covered with the collaboration of the Forest Wardens of the National Institute for the Conservation of Nature (ICONA), who participated in a three part survey. The data collected included additional valuable information on wintering and pseudo-wintering areas and the phenology of their occupation. Given the great mass of data and its relative diversity, its selection, systemization, and synthesis was fairly complex (see Fernández-Cruz et al. 1981).

There was also an enthusiastic response to the publicity campaigns in the press and on the radio, bringing in 287 reports, referring mainly to migration.

WINTERING IN THE IBERIAN PENINSULA

Wintering in Spain

The results obtained in the coordinated national censuses are shown in *Table 1*. Further details, plus a description of the activities carried out throughout 1979-80 can be seen in Fernández-Cruz et al. (1981) where clarifications needed to interpret the censuses are given.

The main conclusions to be drawn from both sources are:

(a) The minimum number of birds wintering in Spain exceeds 14,000 individuals (Census 5). If we add to this the data from Portugal (see below), we see that at least 15,000-16,000 cranes spend the winter in the Iberian Peninsula.

This quantity shows that more than 90% of the birds that breed in Europe choose the "SW route" to migrate (deduced from Cramp et al. 1980). At the same time, it corraborates the findings of Bernis (1960, 1966) in 1957-58, confirming his opinion of the crucial importance of the south-west of the Iberian Peninsula as the main wintering area of the species.

(b) Of the 51 places occupied for shorter or longer periods during the wintering season, 20 were discovered during the present study.

(c) The total number of census-surveys was 357, of which 210 were made on the dates of the coordinated national censuses.

The efficiency and thoroughness of the work carried out has been thrown into relief by Project Grus II, in which only one additional wintering zone was discovered.

Table 1 and the maps in *Fig. 1* indicate the zones occupied by the birds on the dates of the 6 national censuses. They give a fairly clear idea of how the occupation of the different zones changes over the course of the winter. An examination of all the information gathered by the collaborators of the Project has allowed us to define with sufficient clarity the following spatial distribution in large areas of the regions occupied by the birds:

Eastern side. A series of sites from N-S or NNE-SSW (Zargoza, Cuenca, Ciudad Real/Toledo) form a "corridor" of descent for the birds from semihigh to medium latitudes. It receives more than 50% of the crane population coming to the Iberian Peninsula. Although not every place is permanently occupied, it can be seen that during recent years the number of places occupied by only a few birds is diminishing. The preference for a few localities has emerged in the last 15-20 years (See Bernis 1960, 1966). Of these the Gallocanta Lagoon (Zaragoza) has become a true "centre of gravity" of this side; its importance as a wintering and migration zone increases every year.

This side becomes occupied gradually in autumn in a N-S direction, followed by a characteristic split: the main body heads W to occupy the western side, while smaller groups will fly S and SSW to reach the few places existing in the Guadalquivir Valley and the southern cone of the Iberian Peninsula.

In the spring, southern areas seem to be less important, as the birds "short-cut" directly from Extremadura to the Gallocanta Lagoon (usually in a NE direction), and thus the stop-over place (between the eastern and western side) of Belena (Guadalajara) acquires crucial importance.

Western side. These are the principal wintering quarters of the cranes in the Iberian Peninsula. They are distributed among the provinces of Cáceres, Badajoz and Córdoba (with a considerable spearhead into Portugal), although there are also small nuclei in Avila, Toledo, Ciudad Real, Huelva, Seville and Málaga.

Two groups of enclaves, major and peripheral, can be distinguished. The main body of the wintering cranes is found in an eastern nucleus, covering the SE of Cáceres, NE, E and SE of Badajoz, and the NW of Córdoba, and a western nucleus, including the belt of localities covering the SW of Cáceres and the W of Badajoz continuing in the Alentejo in Portugal.

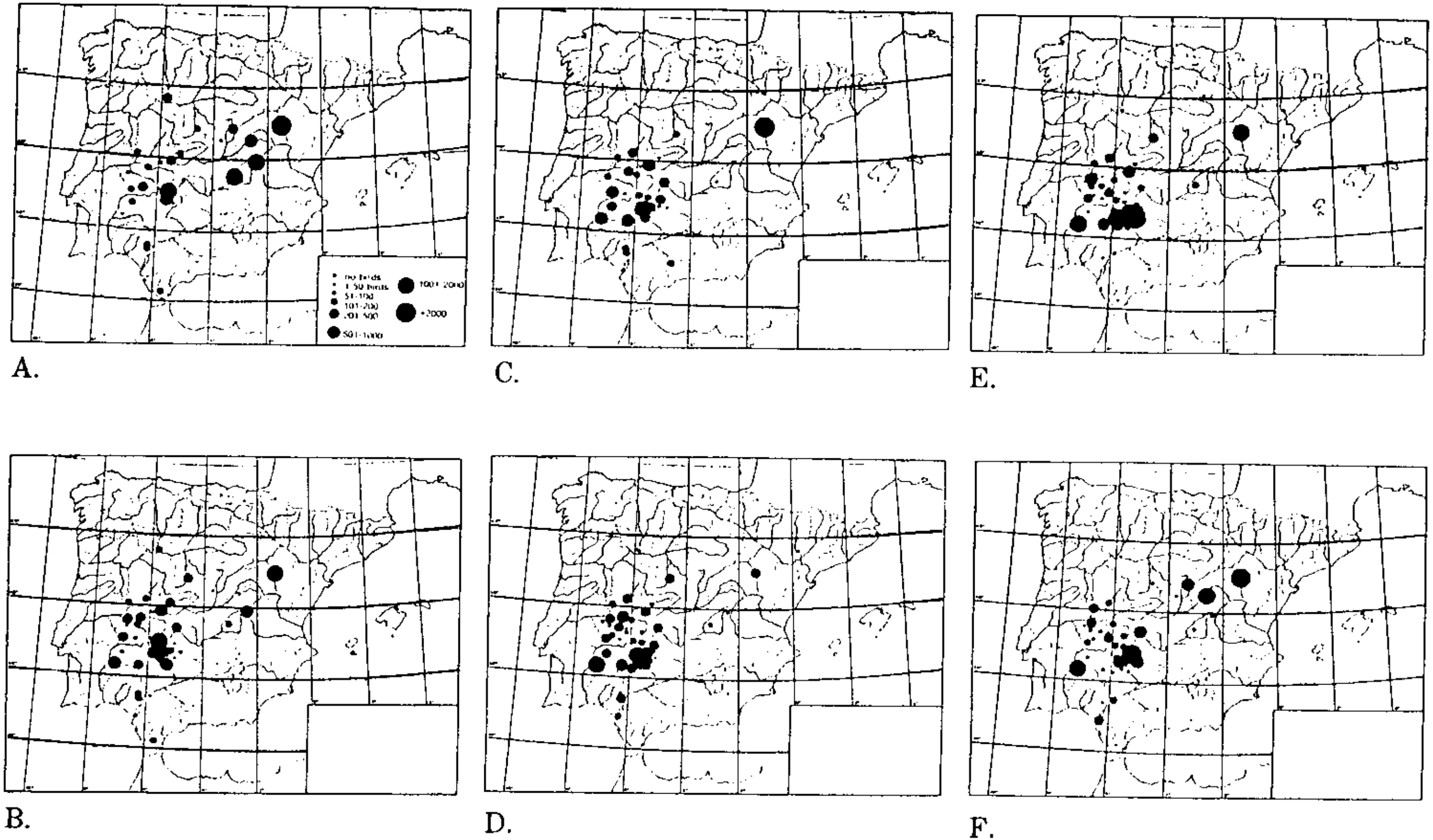

Fig. 1. Distribution of Common Cranes in Spain in 1980. A. 17-18 November 1979; B. 15-16 December 1979; C. 29-30 December 1979; D. 12-13 January 1979; E. 8-10 February 1980; F. 1-2 March 1980.

Table 1. Grus grus. 1979-80. General Censuses.

Date of census	(1) 17-18/11	(2) 15-16/12	(3) 29-30/12	(4) 12-14/1	(5) 8-10/2	(6) 1-2/3	Total number of censuses
Number of birds	9167-9182	11043-11263	9384-9397	11257	14721-14751	12864-13139	
Number of localities	26	35	29	39	44	37	210

Table 2. Comparison of censuses from the Eastern Side (E.S.) and censuses from the "main zones" of the Western Side (W.S.)

General Census	E.S. (nr. of locals)	% of the total	W.S. (nr. of locals)	% of the total	Total birds (nr. of locals)	% of the total (% of locals)	Total Spain (nr. of locals)
1	+5000m(5)	55	3151 (9)	34	8151 (14)	89 (54)	9167-9182 (26)
2	1830-1880 (4)	17	5838 (15)	53	7668-7718 (19)	70 (54)	11043-11263 (35)
3	2089 (2)	22	4968 (13)	53	7057 (15)	75 (52)	9384-9397 (29)
4	494 (3)	4	7577 (18)	67	8071 (21)	78 (54)	11257 (39)
5	1479 (3)	10	8992-9022 (17)	61	10471-10501 (23)	71 (52)	14721-14751 (44)
6	4787-5012 (5)	37	6111-6162 (17)	48	10898-11173 (22)	85 (59)	12864-13139 (37)

Table 3. Comparison among the censuses from Caceres (CC), Badajoz (BA) and Badajoz plus Cordoba (BA+CO).

	Nr. of birds (nr. of locals)	% of the total	Nr. of birds (nr. of locals)	% of the total	Nr. of birds (nr. of locals)	% of the total	Nr. of birds (nr. of locals)	% of the total	Nr. of birds (nr. of locals)	% of the total	Nr. of birds (nr. of locals)	% of the total
CC	724 (7^{1})	8	2149-2306 (8)	19	1647 (7)	18	2529 (12)	23	2539 (11)	17	1543 (10)	12
BA	3151 (9)	34	4995 (13)	45	4968 (13^{2})	53	7051 (16^{1})	63	7422 (18^{1})	50	5604 (15^{5})	44
BA+CO	3151 (9)	34	5838 (16)	53	4968 (13^{2})	53	7577 (18)	67	8922-9022 (20)	61	6111-6161 (17)	48

Exponent means number of localities that are empty (the number in the exponent is included in the base).

The peripheral zones are relatively isolated groups, varying greatly in size and importance. Pure peripheral zones are marginal or semimarginal to the major wintering zone, with modest populations, very localized. We believe that these groups are what remains now of what long ago was the general pattern of wintering, when the whole of the west of the Peninsula was a vast oak forest: many groups of 100-300 birds distributed liberally throughout the forest clearings, along river banks, and in areas planted with cereals and vegetables. Other temporary zones also have small populations, but undergo great fluctuations on certain key dates of both migrations and during movements between pseudo-wintering areas.

Table 2 shows the importance and concentration of birds in certain places in the eastern and western sides; 52-59% of the places throughout Spain contain 70-89% of the birds counted.

Table 3 demonstrates the unequal importance of the wintering places in the provinces of Cáceres, Badajoz and Badajoz/Córdoba. The most immediate conclusion to be drawn is that in Cáceres, a province with peripheral zones, the maximum number of birds counted makes up only 23% of the total, while in Badajoz and Badajoz/Córdoba it reaches 63 and 67% respectively, which indicates the great density referred to above.

Finally, it can be said that the southern zone of the Peninsula shelters peripheral nuclei only, and that the passage to northwest Africa, apart from a few exceptional years, is of almost no importance, concerning only a few hundred birds. Bernis (1960, 1966) pointed out that the importance of northwest Africa as a wintering area has been overestimated.

Laguna de Gallocanta.

Fig. 2 shows the seasonal change in the number of cranes in Gallocanta (Z-1) in 1979-80. Three major conclusions can be drawn:

(a) A high percentage of the crane population wintering in Spain visits this place during the autumn migration and the first third of winter. This behaviour seems to be recent (see Fernández-Cruz et al. 1981) and contradicts the known data for 1957-58 and subsequent years (see Bernis 1960, 1966).

(b) A varying number of birds spend the whole winter there. The exact number is difficult to determine, as it fluctuates according to any extremes in meteorological conditions. It is clear, however, that this behaviour is very recent (in 1973-74 the first seven birds stayed to winter, attracting the attention of the local people) and is increasing sharply. (Project Grus II and oral reports relative to 1980-81 and 1981-82).

(c) There has also been an extraordinary increase in the quantity and density of the spring passage, there being days on which more than 50% of the total of the Iberian wintering population have been counted there.

This massive occupation is due, among other things, to these reasons: generally mild weather during recent winters (according to oral reports to F. Bernis, during the 1950s and before, the Lake and the neighbouring fields were frozen most of the winter), increase in cereal crops (providing the food needed to support a large number of birds) and State protection of the place (declared a Controlled Hunting Zone).

Wintering in Portugal.

Although the factors are not conclusive and the situation could change during particular winters, the surveys made by L. Matos and M. Pinto allow the following generalizations:

(a) The area occupied is centred in the Alentejo, a province bordering on Cáceres/Badajoz and with very similar vegetational features.

(b) Of the total counted (about 1,200 maximum), at least 500 occupy districts bordering on Spain and may be found in the province of Badajoz; excluding these, between 500 and 1,000 birds not counted in any of the 6 coordinated national censuses may winter in Portugal.

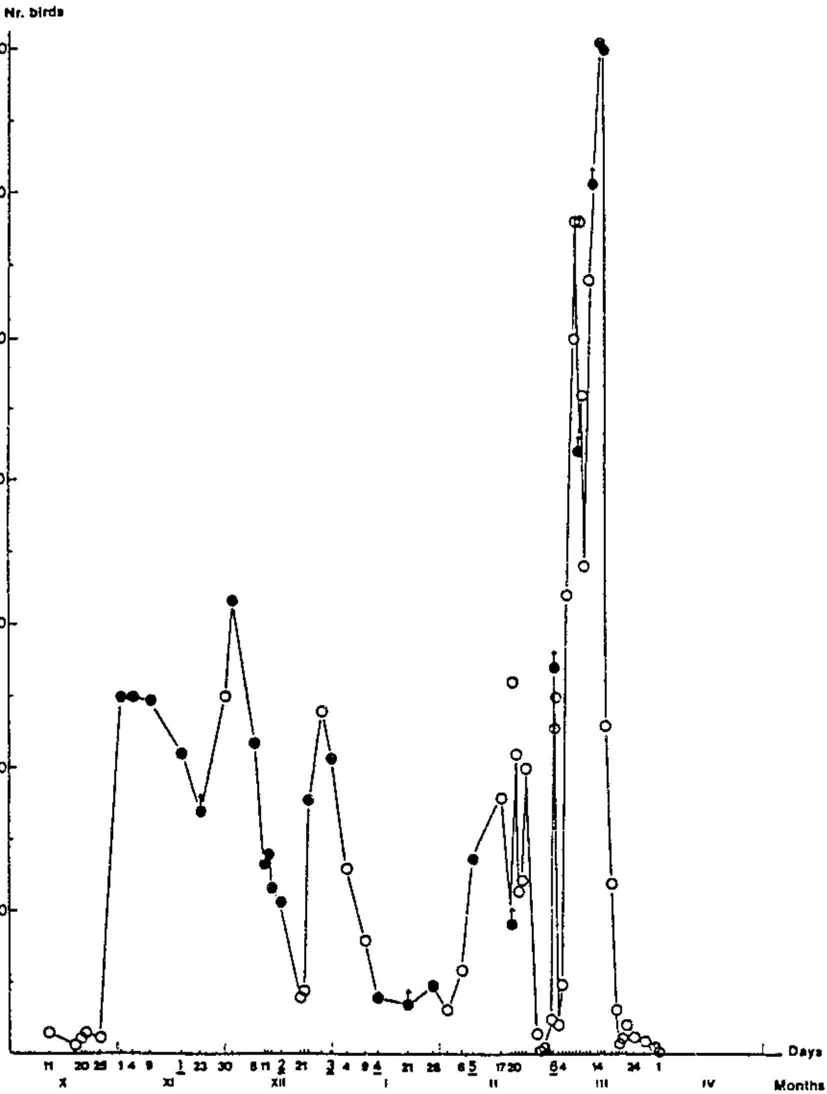

Fig. 2. Seasonal change in the number of cranes in Gallocanta.
o probably *Anser* and *Grus*. • probably only *Grus*

MIGRATION ACROSS THE IBERIAN PENINSULA

Autumn Migration.

This phase extends from the first sighting of cranes (around the last ten days of September) to end of November. This is followed by the phase of "intrawintering movements," between 1 December and the middle of January, in which the birds go from the pseudowintering areas to the wintering ones. Data were obtained from the 781 forms filled in by the ICONA Forest Wardens and covering 25 provinces (see details of this and all that follows in Fernández-Cruz et al. 1981). This information, together with that of P. Petit and collaborators in the SW of France, gave us an overall view of the phenomenon.

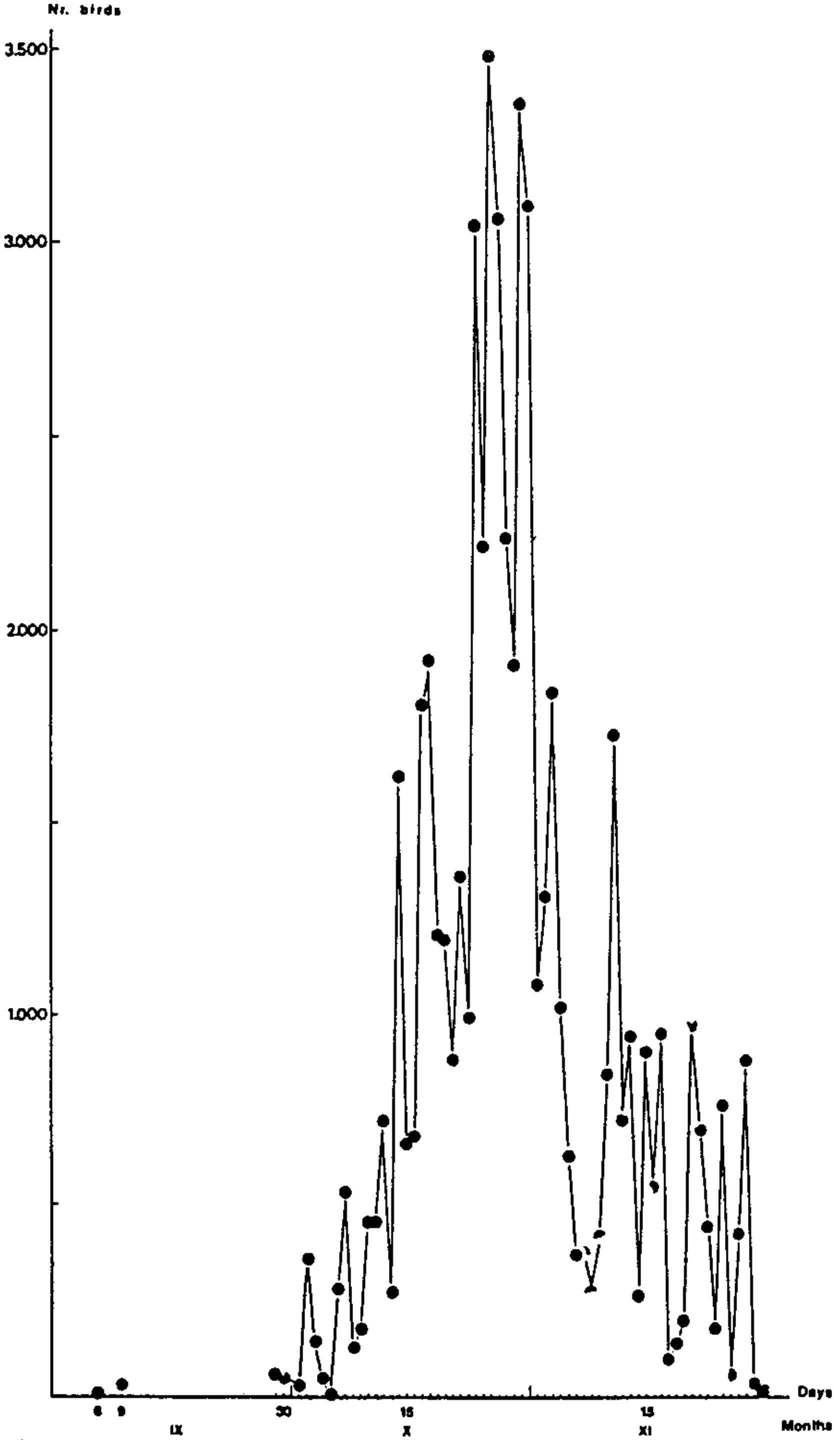

Fig. 3. G. grus Postbreeding Migration, 1979.

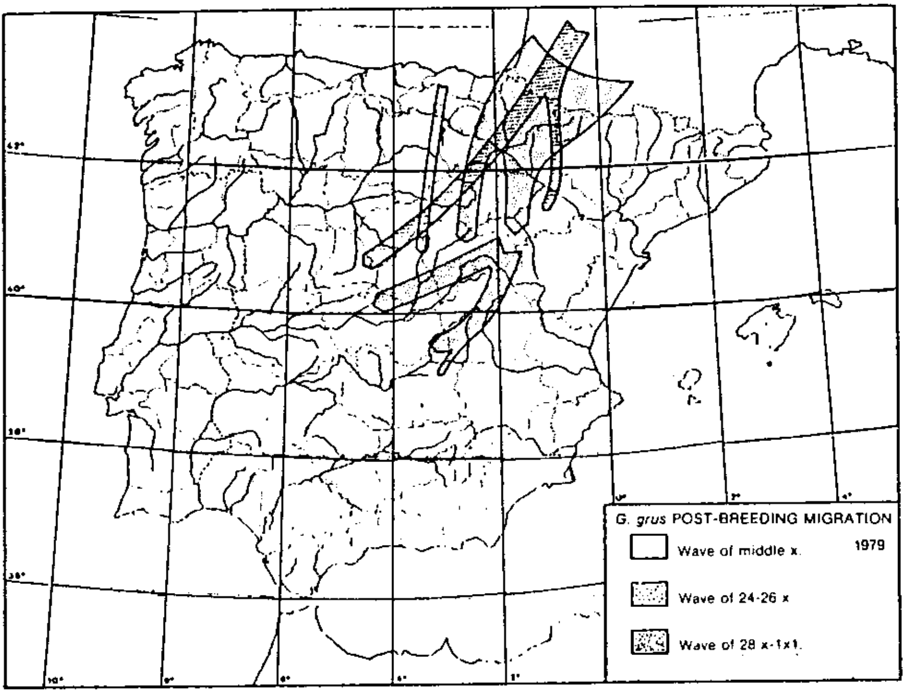

Fig. 4. G. grus Autumn Migration, 1979.

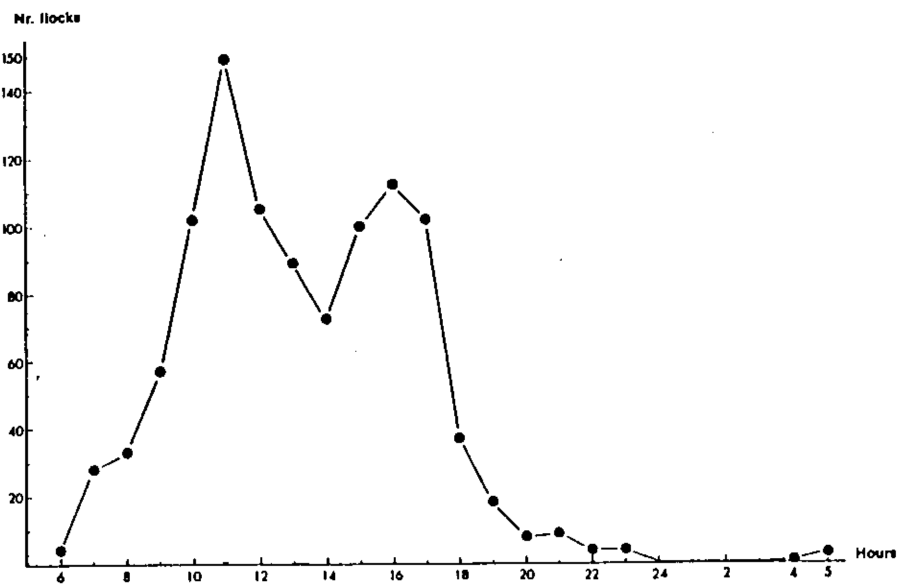

Fig. 5. G. grus Autumn Migration, 1979. Timing of migration.

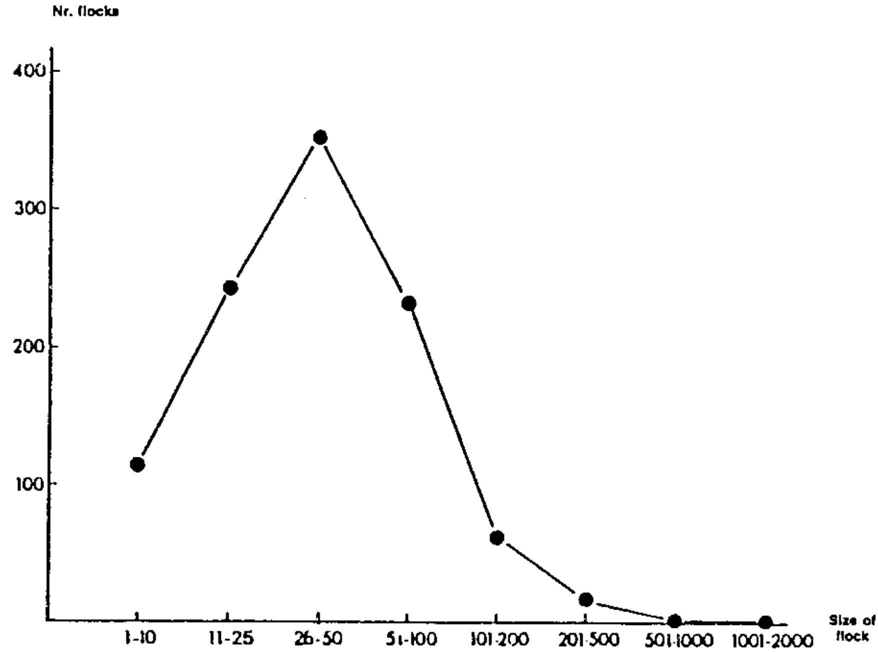

Fig. 6. G. grus Autumn Migration, 1979. Size of the flocks.

Fig. 3 shows the phenology and general quantification. *Fig. 4* has been compiled to illustrate spatial development, where the principal waves of migrants are shown; the entry into Spain over the western part of the Pyrenees stands out clearly. *Figs. 5* and *6* show the times of day during which migration takes place, and the size of the groups. Compare these data with those referring to the prenuptial migration (*Figs. 7-10*).

Spring migration.

This is difficult to define by dates as it coincides partly with the migration of the Greylag Goose (*Anser anser*) and there have been some cases of mistaken identity. However, an exhaustive analysis of all the information received allows the period to be specified between the end of January and the end of March. Crane sightings at the beginning of April are very rare.

Here also it was the ICONA Forest Wardens (with 652 Forms-3) who provided the mass of information, although the data gathered by ornithologists in certain key places were highly significant and illuminating with regard to the above mentioned problem.

Fig. 7 shows the numbers and schedule of the migration. Routes are shown in *Fig. 8*. Two important facts emerge from the figures: the concentration of migrants is 1-20 March, and the departure from Spain over the province of Huesca is further east than the autumn arrival.

Figs. 9 and *10* illustrate the time of day during which migration takes place and the size of the flocks. Note the larger average flock size.

ACKNOWLEDGEMENTS

Proyecto Grus was sponsored by the European Committee for the Prevention of Mass Destruction of Migratory Birds (Project 29) to which, in name of all the members of the Co-ordinating Federation for

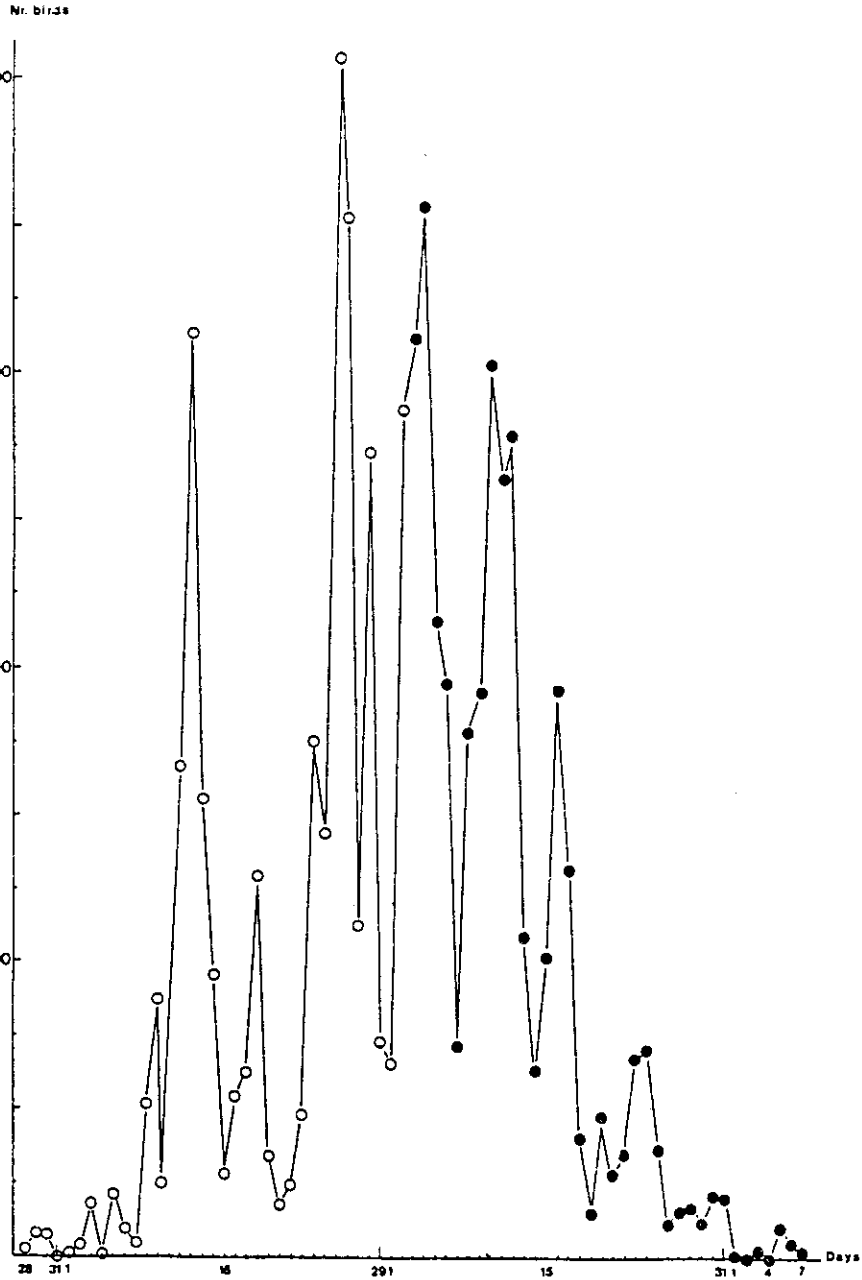

Fig. 7. G. grus Spring Migration 1980. ○ prob. *Anser+Grus* ● prob. only *Grus*.

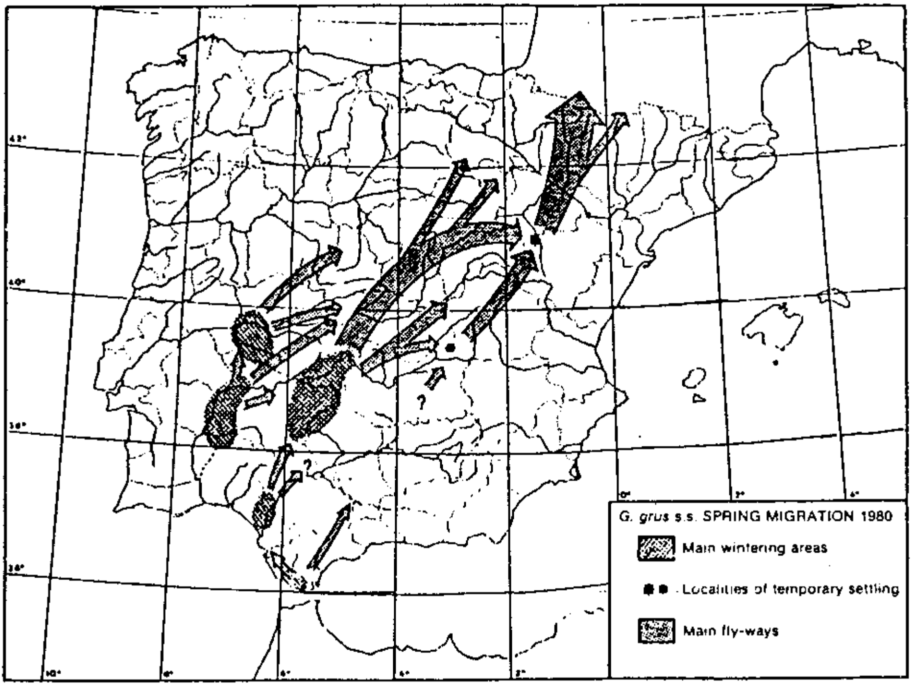

Fig. 8. G. grus. s.s. Spring Migration, 1980.

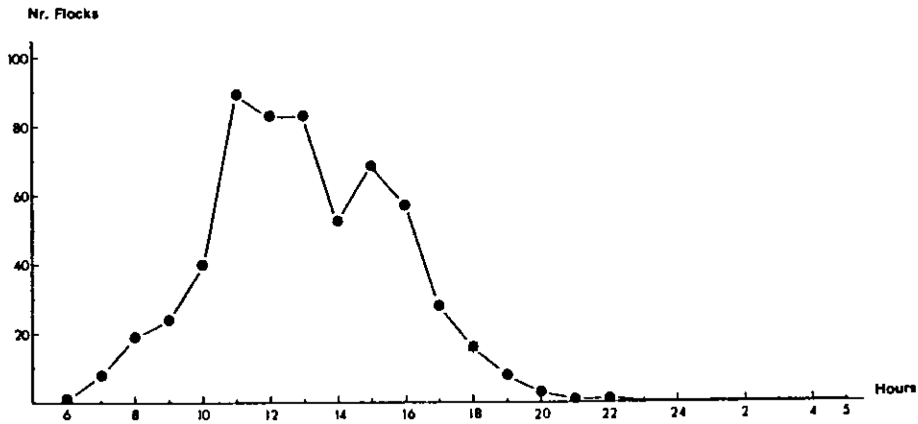

Fig. 9. G. grus Spring Migration, 1980. Timing of migration.

the Protection of Birds (CODA) and the Spanish Ornithological Society (SEO) we express our gratitude for its financial help and for the trust placed in the Spanish team.

Many people collaborated in one way or another; it would be impossible to mention everyone. Nevertheless, we do not wish to omit Joaquin Araújo (who thought of the Project in the first place), F. Bernis (guarantor of our request, friend and coparticipant in many ideas), José Lara (Director of ICONA) and Imre de Boroviczeny (who liaised with the Committee and whose dedication and efficiency were "to blame" for the success of this project); all the ornithologists in CODA and SEO, who carried out the enterprise; and my colleagues in the Vertebrate Department of the Madrid Complutense University who lived and and suffered with cranes in unison with us.

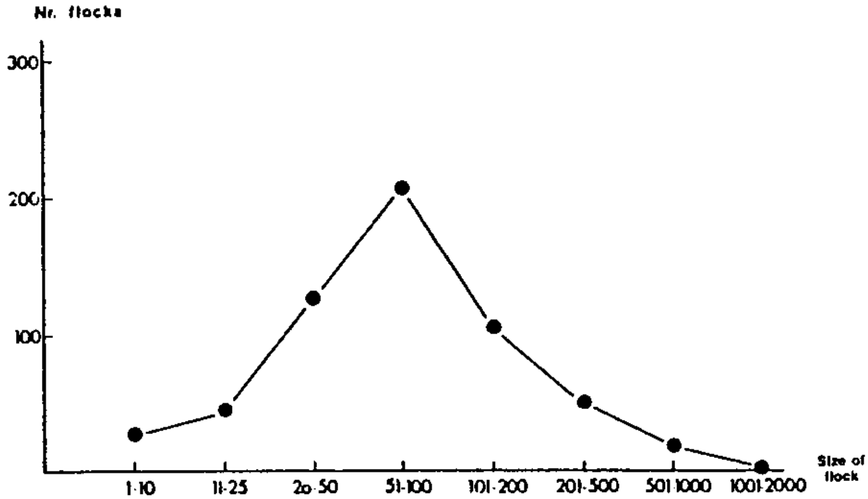

Fig. 10. G. grus Spring Migration, 1980. Size of the flocks.

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CRANE PROJECT II
MIGRATION AND WINTERING OF THE COMMON CRANE IN SPAIN DURING AUTUMN AND WINTER OF 1980-1981

JOAQUIN ARAÚJO-PONCIANO

Compiled by: Angeles de Andrés,
Carlos de Hita,
José Manuel Reyero, Rafael Serra,
Coordination: CODA

INTRODUCTION

Crane Project I, carried out in the Autumn and Winter of 1979-80, can be considered, both in terms of field work and of the analysis of the results, as one of the best and most ambitious studies ever made by a large team of Spanish ornithologists. The funds granted to CODA by the European Committee for the Prevention of Mass Destruction of Migratory Birds were what made possible these wide-ranging surveys, the repeated deployment of 125 people, and the carrying out of six general censuses. Adding to this the extensive collaboration of the Wardens of the National Institute for the Conservation of Nature (ICONA), complete data was obtained for the first time on the movements and wintering of cranes in Spain. The data gathered are contained in a detailed report drawn up by the Project's Coordinator, Dr. Manuel Fernández-Cruz.

Bearing in mind, however, that the study made in 1979-80 was the first exhaustive one ever made on the subject, it was immediately seen that a repeat of the Project, albeit on a minor scale, was essential in order to make sure that the number of cranes and their behaviour in 1979-80 could be considered typical, or if there were major differences from one year to another. The ultimate aim of the Crane Project was to make specific proposals for the effective protection of these birds and of the areas most important to them during their stay in Spain. Such proposals could not be made responsibly without the prior verification of the first year's results.

It was therefore agreed to repeat the Project. Once again the European Committee provided the necessary funds. For personal reasons, Dr. Fernández-Cruz was not able to continue in his role as Coordinator of this second Project, and thus the CODA Executive had to take charge of it.

PLANNING, METHOD AND MATERIALS

The principal aim of Crane Project II was to verify the results of the previous project by means of "spot checks" and of three wider-ranging censuses which would establish with certainty the most important areas to be protected. It was also decided to make an in-depth study of the three key wintering zones and stopover places. The number of collaborators was reduced to about half that of the previous year. We were aided this time by the valuable cooperation of our colleagues in the south of France, whose data on migratory movement were of great importance in completing the data obtained in Spain.

The censuses were made on the following dates: 9 - 11 January, 6 - 8 February, 27 - 28 February and 1 March.

During 25 days of observation, a wintering zone in the Province of Badajoz was studied exclusively by two ornithologists, Carlos Sanz and Pilar Pareja. As well as observing the behaviour of the 4000-5000 cranes there, their main object was to discover the extent of the area needed by a flock of cranes during the sedentary phase of wintering.

The second key point chosen was the region of Belena in the Province of Guadalajara, which is a vital "corridor" during the prenuptial migration. The DALMA group from Guadalajara put in a great deal of work, including 22 days of observation, establishing that throughout the second fortnight in February and the first in March, more than 50% of the wintering populaiton of cranes pass through this corridor.

Finally, two groups of ornithologists, working independently of each other, studied the zone of Gallocanta, of crucial importance for the cranes. At least 70% of the cranes gather at this point before their departure for France. Moreover, counts and studies made here before the Crane Projects by the Grupo ARAGON de Ornitologia show that the number of cranes in the area all through the winter is still growing, thus causing an increasing problem for the local farmers.

Given that the 1981 general censuses were mainly of a "checkup" nature and thus did not provide the total figure of wintering cranes, the Gallocanta results do however serve to bear out this parameter. On 5 March, 12,135 cranes were counted in Gallocanta; during the days immediately preceding, the French had observed the passage of between 3000 and 5000 cranes through the south of France that had evidently come from Spain. From this we can deduce with all certainty that at least 16,000-17,000 cranes had wintered in Spain during the 1980-81 season.

MIGRATION

Studies made during Crane Project II regarding routes, pseudowintering areas, and movements between them and the wintering places proper have fully confirmed the results of the previous Project. For easier reference, all these data are present in *Table 1.*

The only difference between movements in 1979-80 and 1980-81 was the slight delay in the second year compared to the first. A drought, which was fiercer during Grus II than in the previous year, affected the crane groups in two ways: firstly, bringing large numbers to Gallocanta, thus increasing the importance of this lake; and secondly, forcing the birds to reach their wintering places sooner.

The dates of departure were also slightly earlier than in previous years, which could also be explained by the drought.

WINTERING

As mentioned above, the Grus II censuses were not general censuses in the strict sense of the word, but "spot checks" (*Table 2*). Here also the comparisons made with the previous results bear them out, thus providing extremely valuable information for specifying the areas in need of protection (*Fig. 1*).

The counts made at the end of February and the beginning of March permit us to estimate that in 1980-81 about 1500 more cranes wintered in Spain than in 1979-80. This oscillation seems to us quite normal, even discounting human error of calculation. It seems

Table 1. Provincial spot checks of key sites from October 1980 to March 1981. Each count refers to one or two sites only. For situation of Provinces, see attached map. Gallocanta lies in the SW of Zaragoza Province.

Gallocanta:	Dec.	21 -	5,032	Zamora:	Oct.	18 -	9
		22 -	4,898		Nov.	3 -	380
	Jan.	2 -	818			8 -	403
		23 -	1,259			29 -	400
	Feb.	14 -	4,330		Dec.	9 -	70
		20 -	5,032			10 -	8
	Mar.	2 -	6,000		Feb.	10 -	200
		4 -	11,438			21 -	6
		5 -	12,000				
		7 -	7,458	Caceres:	Oct.	31 -	11
		8 -	6,000		Nov.	2 -	44
		13 -	2,550			22 -	187
		14 -	945			30 -	202
		23 -	21		Dec.	18 -	228
						19 -	264
Guadalajara:	Nov.	2 -	288		Jan.	4 -	548
	Jan.	21 -	324			25 -	300
		23 -	2,070		Feb.	23 -	35
		25 -	248				
	Mar.	2 -	233	Badajoz:	Nov.	23 -	4
		5 -	432		Dec.	6 -	100
		8 -	464			9 -	1,022
						21 -	4,791
Cuenca:	Oct.	23 -	77		2Jan.	2 -	3,692
	Jan.	3 -	62			3 -	5,573
						4 -	2,511
Madrid:	Oct.	18 -	55		Feb.	13 -	2,137
	Nov.	2 -	153			23 -	1,043
		9 -	138			26 -	1,205
	Feb.	23 -	1,824		Mar.	2 -	425
	Mar.	8 -	125			3 -	246
						7 -	26
Toledo:	Oct.	28 -	19				
	Nov.	23 -	120	Huelva &	Nov.	15 -	8
	Dec.	5 -	445	Seville &	Dec.	6 -	400
		31 -	350	Cadiz:		18 -	300
	Jan.	25 -	350			23 -	475
	Feb.	23 -	190			30 -	460
	Mar.	7 -	375		Jan.	3 -	4
		9 -	80				
C. Real:	Jan.	25 -	158				
Avila:	Oct.	18 -	30				
		28 -	135				
	Nov.	1 -	35				
		15 -	215				
	Dec.	14 -	90				
		29 -	144				
		24 -	159				

Table 2. Grus grus. 1981 General Censuses (spot checks).

Date of census	9/1	10/1	11/1	6/2	7/2	8/2	27/2	28/2	1/3
Number of birds	2,175	7,756	1,267	3,012	7,728	2,949	9,700	11,216	10,173
Number of localities	2	7	5	2	12	10	3	12	16
Number of birds in: Caceres and Badajoz	n.c.	5,724	1,202	n.c.	4,708	2,674	803*	3,095	1,996
Gallocanta	2,000	1,507	n.c.	2,800	2,632	n.c.	8,531	7,561	4,446

n.c. = not counted: * =Badajoz only

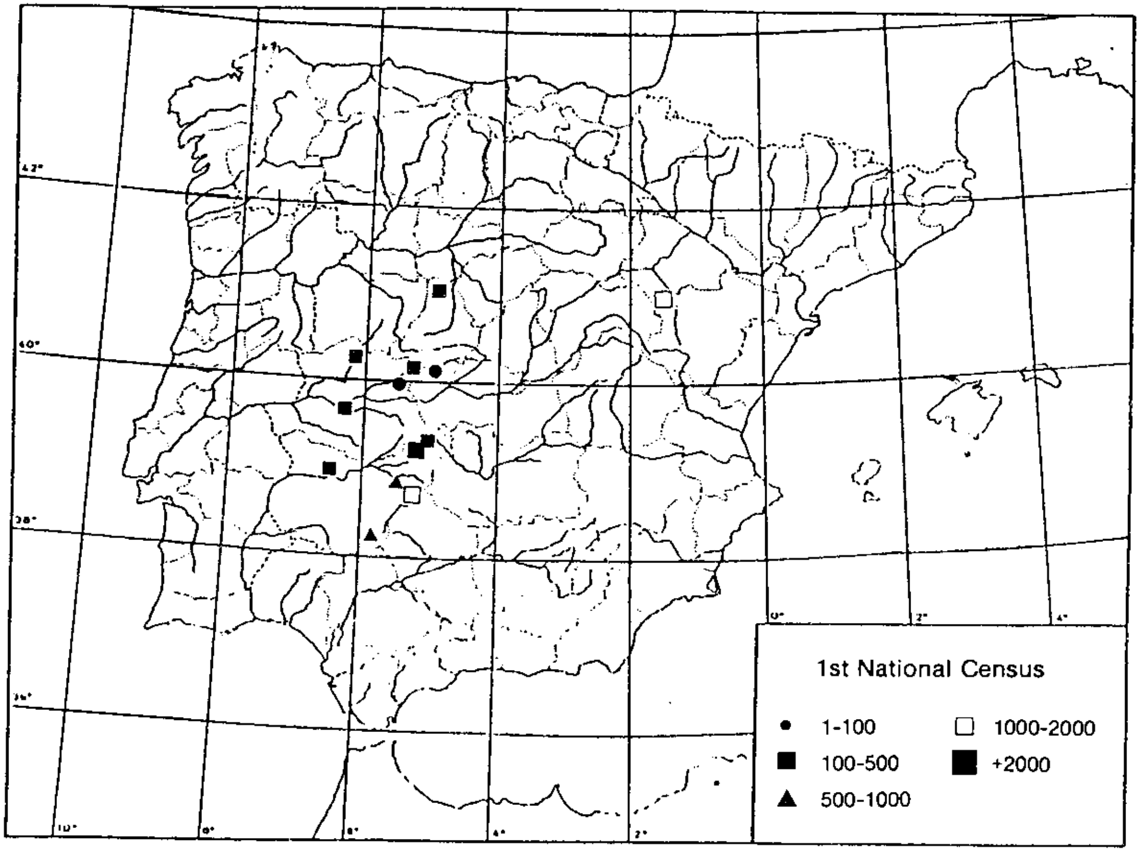

Fig. 1A. Distribution of Common Cranes in Spain in 1981. 9-11 January.

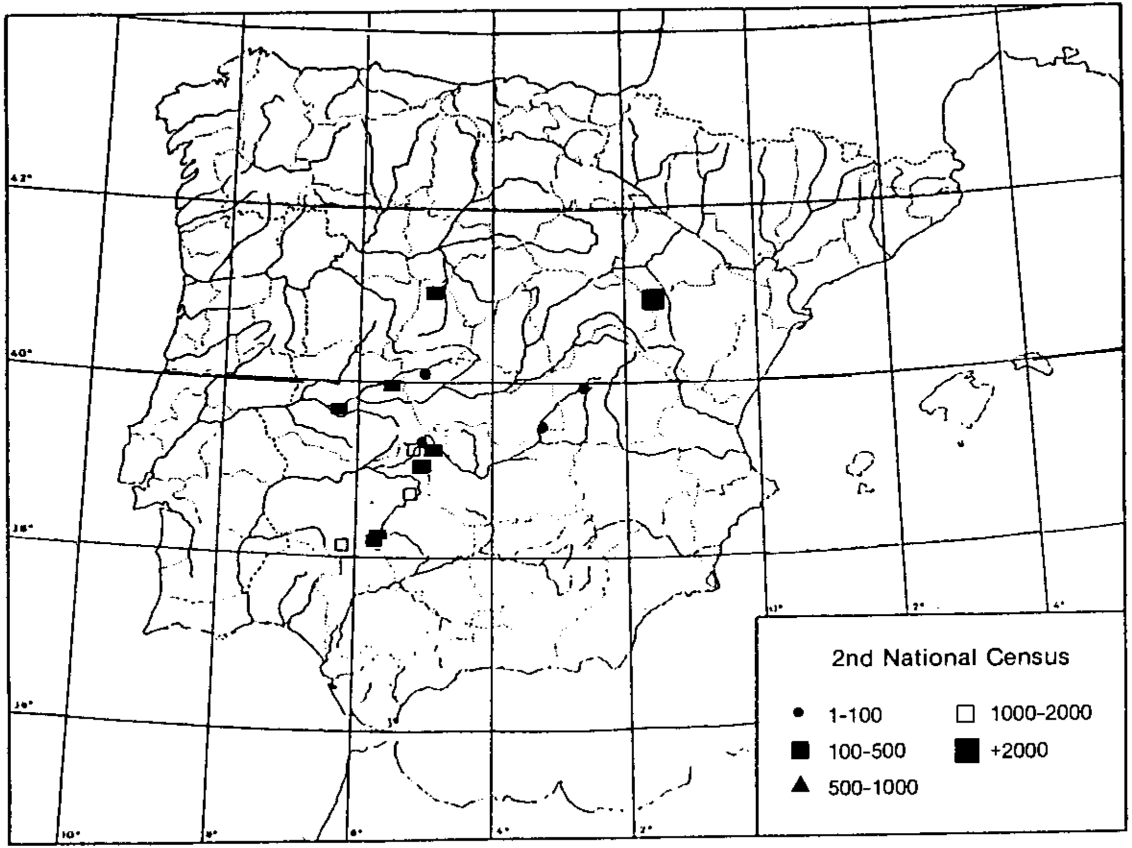

Fig. 1B. Distribution of Common Cranes in Spain in 1981. 6-8 February.

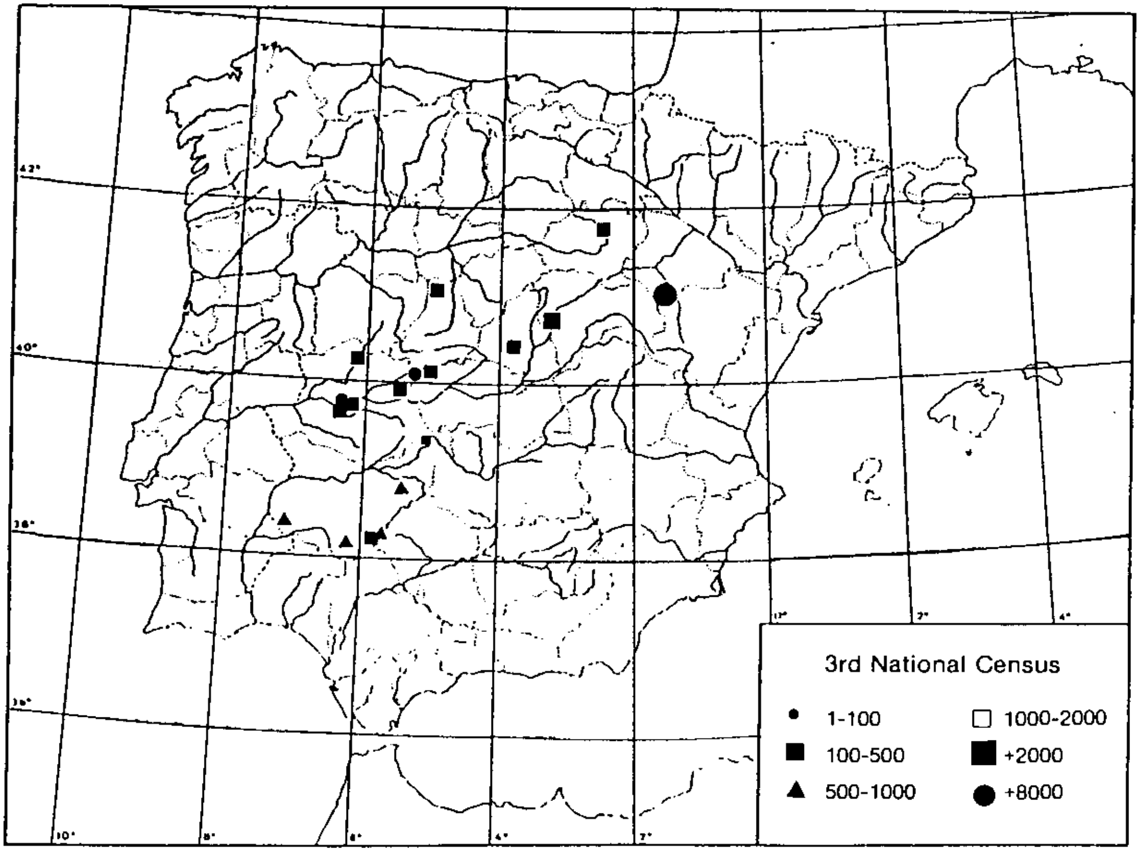

Fig. 1C. Distribution of Common Cranes in Spain in 1981. 27 February-1 March.

clear that an important fraction possibly over 50% of the total crane population of our sector of the Western Palearctic winters in the Iberian Peninsula and in the south of France; also it is plausible that some groups may change route occasionally and head, for example, for the Italy-Tunis corridor.

LOCAL STUDIES IN BADAJOZ, GUADALAJARA, AND ZARAGOZA

Badajoz: Observation of the Behaviour of a Group of Cranes Wintering in the District of La Serena.

There is no doubt that, when attempting to protect a species, it is essential to have as much detailed knowledge as possible regarding the extent and characteristics of its habitat. Therefore, throughout Project Grus II, many working days were spent studying just one wintering nucleus of cranes, perhaps the largest one in Extremadura.

Twenty-four days were spent studying the group: following the birds in their movements between roosting places and feeding grounds, watching their behaviour during the day, noting the composition and behaviour of the groups in the grazing areas as well as in their roosting places. We came to the following conclusions:

Large concentrations are more vulnerable than smaller ones.

Dry roosting places - that is, not close to lakes - are subject to sudden changes.

The grazing area of a population of ±2000 cranes can exceed 600 to 700 sq.kms.

Flyways and flight routes are fairly stable, and thus their protection should be emphasized.

Crop damage can be major. Thus compensation for farmers is a possibility to be borne in mind.

Weather is a direct influence on group behaviour.

The members of a flock are not necessarily stable, that is, transfers are frequent.

Effective protection includes consciousness-raising campaigns in principal zones and clear hunting controls.

Guadalajara: The Crucial Migratory Flyway of the Lagunas de Belena.

Various points on the Spanish landscape appear to be of crucial importance to the wintering and migratory movements of the birds. The prenuptial flight has been carefully studied in one place in the province of Guadalajara, in central Spain, through most of February (*Fig. 2*).

As can be seen, rather more than 50% of the cranes wintering in Spain use this flyway, which, along with others mentioned elsewhere, should at least be watched. With regard to times of flying, it is interesting to note that the cranes cover up to 400km in one flight between the Tajo Valley and Gallocanta, as there seem to be no intermediate places with optimal conditions for roosting. On the other hand, it is very likely that the cranes are obliged to land in the district of Belena, thus increasing the importance of this zone.

Zaragoza: Laguna de Gallocanta.

To what has already been said, we shall only add here that Gallocanta is not only the gathering place for thousands of cranes and the last stop over before the departure for France, but that it is becoming the most controversial of the crane areas in Spain (*Fig. 3*). Local farmers allege that cranes cause a great deal of damage, in spite of the practice of scaring them off with rockets. Several tentative solutions have been proposed, e.g. the purchase of estates which would be baited to attract most of the cranes, compensation, drastic dispersion of the cranes so that they would stay away, etc. None of these proposals, however, is based on any kind of prior research. What is obviously needed is a serious study, going into detail on the real effects of the cranes on Gallocanta. We shall come back to this subject in the recommendations that follow.

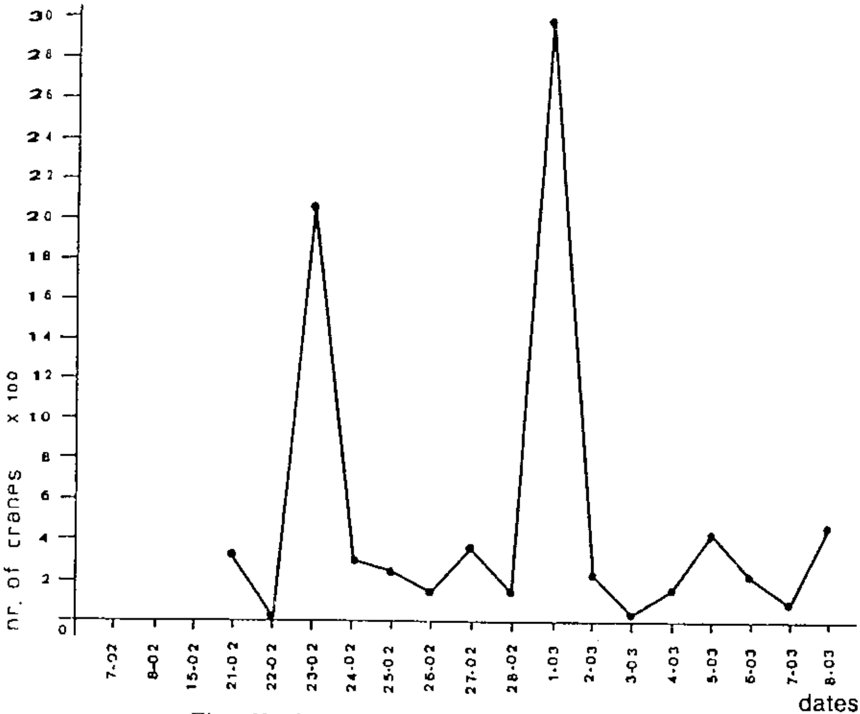

Fig. 2. Numbers of Common Cranes at Lake Belena in 1981.

Fig. 3. Numbers of Common Cranes at Lake Gallocanta during the winter of 1980-1981.

RECOMMENDATIONS

Project Grus II has fully borne out the findings of the previous season, so that, basing our reasoning on the results of the two Projects, we can purpose a series of recommendations for the effective protection of the Common Crane in Spain (*Fig. 4*).

The Grus Projects have shown that cranes depend in great measure on the woods, seedling crops, and pastures of Extremadura. Given the overwhelming disappearance of the oak forests and the increasing deterioration that highly technical agriculture causes in agrarian ecosystems, we advocate, in the first place, the conservation and even the improvement of these natural systems. Although we know that cranes can subsist in treeless country on the seedlings of cereal crops, it has been proven that there are so few sufficiently safe roosting places that the cranes concentrate in them at greater risk.

The conservation of the oak forests would ensure that cranes would stay in many marginal locations, especially in Extremadura. We are referring mainly to groups of one hundred to three hundred birds, on average, whose preference for these places would guarantee greater safety. This pattern of wintering was the principal one when the oak forests stretched uniformly over the region of Extremadura. Consequently, we call for urgent, specific, and realistic measures to be taken to stop the felling of the oakwoods.

We submit the following specific measures to ensure the protection of the Common Crane and its habitat in Spain:

1. That the current Decree regarding Protected Species be applied with maximum rigour.
2. That the conservation of the forests of Extremadura as one of the biotopes vital to the crane be ensured.

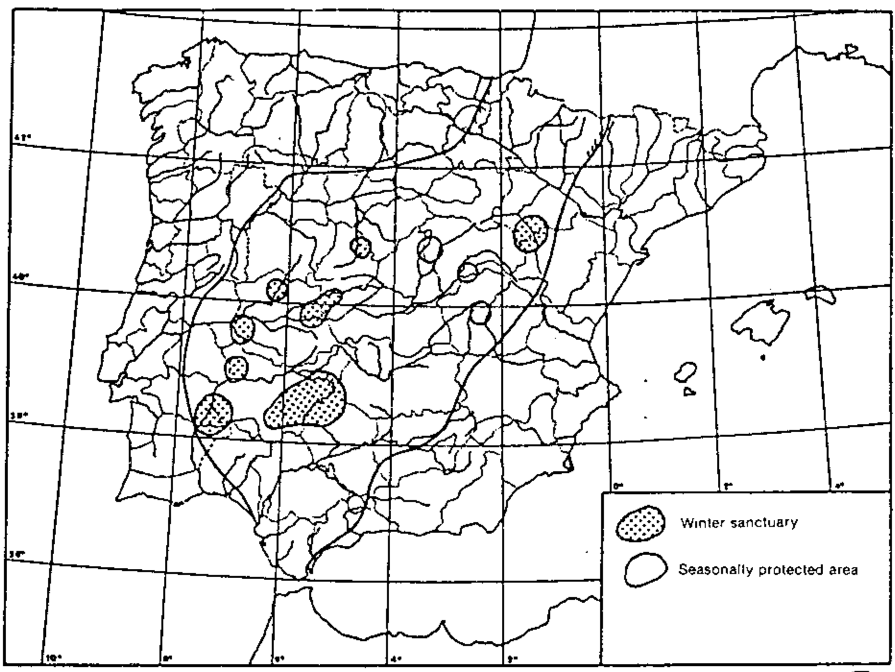

Fig. 4. Areas that should be protected in Spain: (dotted) protection of cranes and winter habitat; (open) protection of cranes.

3. That the following zones be declared protected areas by the relevant authorities:
   a. Winter Sanctuaries.
      1. at Laguna de Gallocanta area (Zaragoza-Teruel)
         Los Pedroches-La Serena area (Badajoz-Cordoba)
         Cheles-Villanueva del Fresno-Alentejo Oriental area (Badajoz-Portugal)
         these being the three main wintering centers.
      2. Gabriel and Galan area (Caceres)
         Casas de Santa Isabel area (Avila)
         Navalmoral de la Mata-Embalse de Rosarito-Navalcan area (Caceres-Avila)
         Brozas area (Caceres)
         Villar del Rey area (Badajoz)
         these being the already scarce peripheral places.
   b. Seasonal Reserves.
      Lagunas de Belena area (Guadalajara) between 1 February and 31 March.
      Embalse de Buendia area (Guadalajara) between 1 Oct.-15 Dec. and 1 Feb.-31 March.
      Laguna de El Hito (Cuenca) area, between 1 Oct.-15 Dec. and 1 Feb.-31 March and in the intermediate periods during years with stable winters.
      Laguna de Fuente de Piedra area (Malaga), between 1 Oct.-15 Dec. and 1 Feb. to 31 March.

c. Protection of migratory flyways, centred particularly on the following zones;
   Pyreneen passes
   Embalse de la Sotonera (Huesca)
   Laguna de Gallocanta
   Lagunas de Belena.

CONCLUSION

The Crane Projects' logical conclusion is that pressure be exerted for the protection of the main wintering sites of these birds in Spain. Two main circumstances have so far delayed this action:

1. In accordance with the new, 1978 Spanish Constitution, Spain is in the process of being segmented into Autonomous Regions, each one of them with almost complete autonomy and jurisdiction in all matters relating to nature conservation and use of natural resources. Thus the delimitation of protected areas in Extremadura (Caceres and Badajoz Provinces) and other regions will have to be negotiated with the Regional Governments and not, as until recently, with the State Nature Conservation Authority (ICONA). Moreover, the two fundamental State laws relating to the subject, i.e. Law of the Environment and, within the framework of this, Law of Nature Protection (which is to redefine the catalogue of areas protected by law), originally promised by the State Government to be sent to Parliament in June and November 1983, have, at the time of this writing, not even reached the final draft stage. Consequences: The first really serious contracts and discussions between CODA (through its President, J. Araujo) and the Extremaduran Regional Government have taken place as recently as early December of 1983. Hopefully, serious talks about to-be-protected crane areas in Extremadura will be taken up more or less early in 1984. Apart from this, the protected Nature Protection Law seems to contemplate the figure of "temporary reserves," which could be quite important for crane sites. It still remains to be seen, if we would be better to wait for the new law, or if adequate "pre-law" solutions can be found.

2. Since early summer 1983 the ICBP "Important Bird Areas" project is under way in Spain. This project is to delimitate all bird areas that should be protected by Spain's central Government in accordance with International Conventions (Migratory Species Protection; Wildlife & Natural Habitats Protection; EC Bird Protection Directive). Depending on timing, it might be useful to couple crane sites with more general bird sites (as very often a crane site is important for other birds too) and thus give the crane-site-protection request added importance.

POSSIBLE EFFECTS OF RECENT AGRICULTURAL DEVELOPMENT ON THE WINTERING AND MIGRATORY PATTERN OF COMMON CRANE IN IBERIA: A STUDY OF WINTER ECOLOGY IN A SUITABLE LOCALITY

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ABSTRACT

The wintering range of the Common Crane (*Grus g. grus*) traditionally extends over wide areas from the central Iberian peninsula to northern Morocco. During the last decade, cranes have increasingly used the Laguna de Gallocanta (NE Spain) as a staging area during both postnuptial and prenuptial migrations and in winter. Particularly during 1981-82 season, that locality represented the principal staging and wintering area for the Western European population, with peak numbers of nearly 10,000 cranes in autumn and spring and about 30% of the Iberian wintering population remaining there between the migratory peaks.

Research findings indicate that among factors determining the progressively increasing use of Laguna de Gallocanta as a staging-wintering area, those related to food supply abundance play a definitive role. Additional important factors include the low topographic relief of the lake basin, the shallow water level, and the restricted hunting in the zone. Recent mechanization and intensive cultivation have resulted in considerable cereal grain waste, which provides the cranes a continuous food source. The authors analyze the similarity between the seasonal variation of cereal-food availability, which is determined by the crop phenology, and crane numbers in the study area, and relate it with the recent deteriorations and habitat transformations at other Iberian wintering areas. Ecological parameters such as distribution of foraging cranes in fields, age structure, composition and size of the flocks, and distance from feeding sites to roost, and certain demographical aspects are investigated. Suggestions for management are presented.

INTRODUCTION
THE WINTERING OF COMMON CRANES IN IBERIA: HISTORICAL PERSPECTIVE

Early reports on migration of the Common Crane (*Grus grus*) indicate that the NW Africa (Morocco, Tunisia, Algeria) was the main winter quarter for the western population of the species (Irby 1895, Verner 1909). Later, Bernis (1960, 1966) assessed the importance of SW Iberia and the decreasing significance of crane numbers crossing the Straits of

Gibraltar. He estimated the Spanish wintering population between 5,000 and 15,000 cranes distributed over 150 localities.

In 1979-80, the number of Spanish wintering localities was reduced to 51, while the total of cranes remained around 15,000 and migration through Gibraltar was considered to be negligible (Fernández Cruz et al. 1981). The study documented several Spanish wintering localities each involving more than 1000 birds, and stated the importance of Laguna de Gallocanta as a wintering and staging area during migration.

Crane studies continued in that locality, and the significance of the area for the species was emphasized at the VI Workshop on Iberian Ornithology (Alonso et al. 1983). Other studies report on aspects related to geology, biology, human activies, and contamination sources in the zone (Proyex 1980, 1981).

The Laguna de Gallocanta is a saline lake with a water surface of 1400ha and a maximum depth of around 2.5m in wet years. It lies in a basin of 53,637ha and is surrounded by intensively cultivated cereal farmland (mainly wheat and barley) characterized by flatness of the terrain and absence of woody vegetation. Beside this, waterfowl hunting has been restricted in the area since 1972 and human disturbance is negligible. (*Fig. 1*).

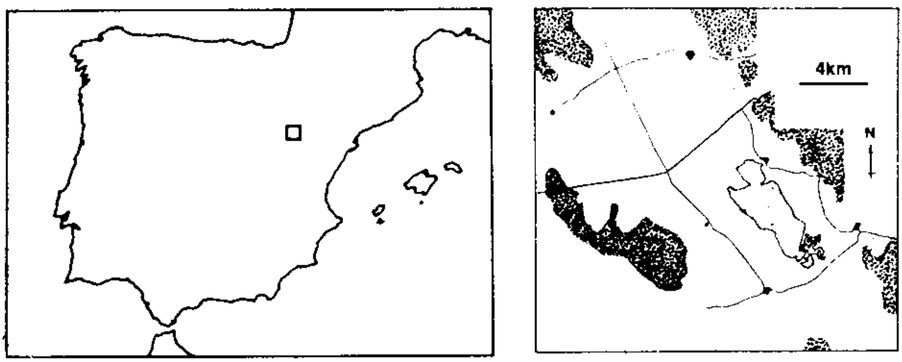

Fig. 1. The study area. Gallocanta lake is located in the center of the map on the right. *Quercus*-wood areas (shaded areas), villages and roads are also represented on the map.

This paper is based mainly on data collected at Gallocanta during the 1981-82 winter season, but field observations of 1979-80, 1980-81 and 1982-83 and other references from various sources have been also included. The study has focused on analyzing certain biological patterns of the cranes and some ecological parameters relevant to a full understanding of the role of Gallocanta as a staging locality and the possible effects of agricultural changes in relation to distribution and protection of the species in Iberia.

MIGRATION AT LAGUNA DE GALLOCANTA

Cranes first began to stage in Gallocanta during the spring migration of 1973-74. During the following years, there has been a progressive increase in the numbers of cranes staging there in spring as well as in fall migration (*Fig. 2*). Since 1980-81, the mean and the maximum occupation during both migrations has tended to stabilize. The presence of cranes in the area during the winter was recorded for the first time in 1973-74, even though during this and the following winters only a small number of birds remained there throughout the whole season. Wintering cranes are considered to be those present in January. The quantity of birds spending the winter in the zone showed a drastic growth beginning in 1979-80. In the 1981-82 season, the size of the wintering population was extraordinarily large: 5000-6000 birds (Alonso et al., in prep.). During the present year (January 1983) numbers have averaged around 400 cranes.

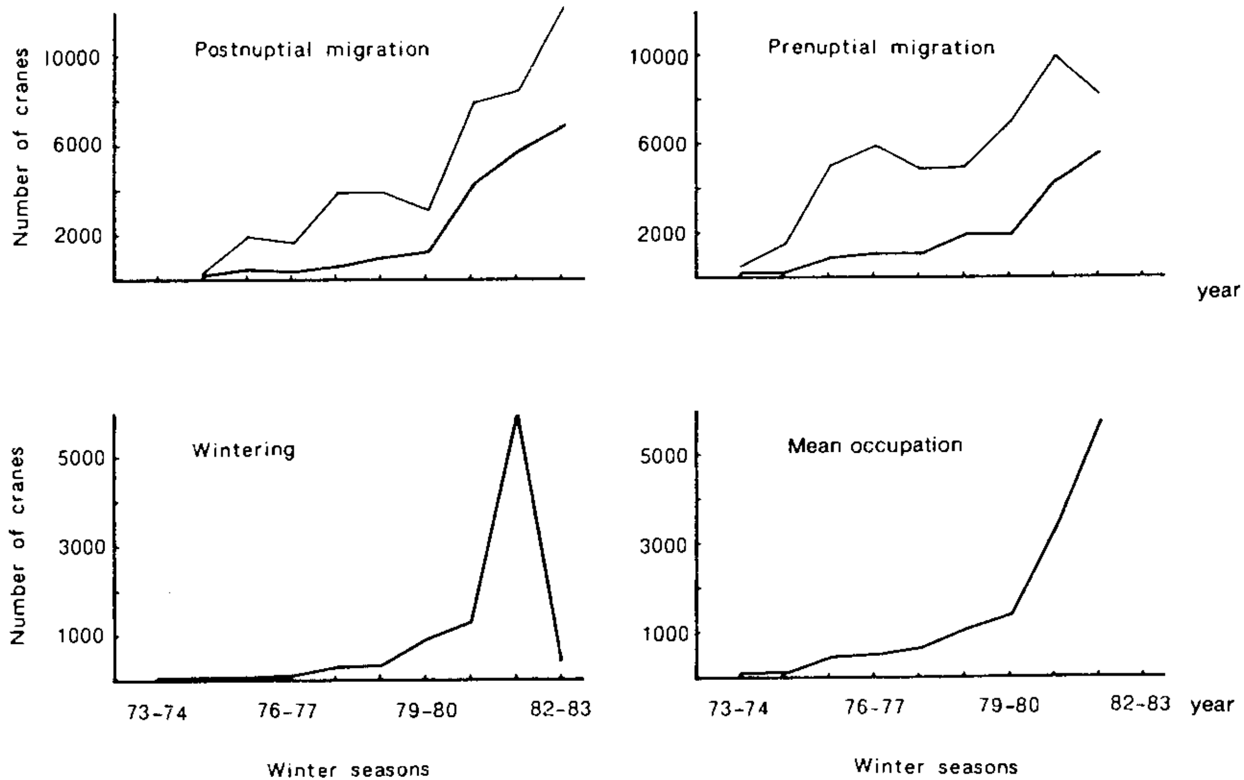

Fig. 2. Annual peak (thin line) and average (thick line) numbers of Common Cranes using the Laguna de Gallocanta as staging area. Postnuptial migration of October-December; wintering - January; prenuptial migration of February-March. Average figure.

According to the data obtained in the past three years, the occupation period extends from late October-early November to late March-early April (about 160 days), even though the bulk of the birds stay there between mid-November and mid-March. The staging during fall migration is more spread out than the spring staging (*Fig. 3*). The rise in the percentage of juveniles at the end of the staging period means that juveniles are leaving family groups in late February and early March as adults migrate (Alonso et al. 1983).

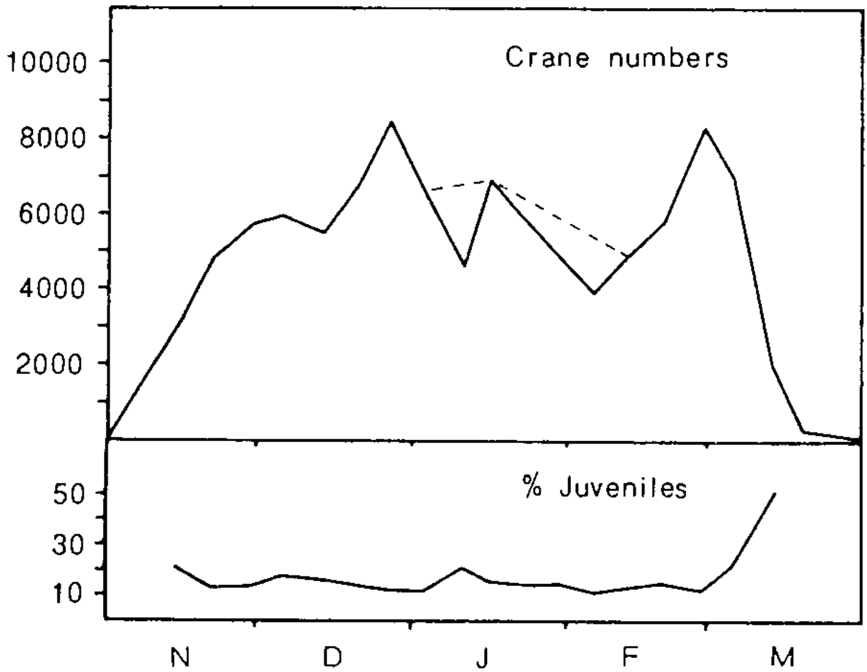

Fig. 3. Seasonal changes in number of cranes and in juvenile percentage during 1981-82. Dashed line joins the most accurate midwinter censuses.

WINTER ECOLOGY

Recent Evolution of the Agricultural Features in the Study Area

According to Marín Cantalapiedra (1973), the province of Zargoza leads Spain in numbers of mechanical harvesters and in horsepower, and is second in tractors. Agricultural mechanization parameters (Ha/tractor and Ha/harvester) surpass mean figures for the whole of Spain, and during 1960-70 (Figures for 1970-80 are not available.) those values underwent a drastic increase (448% in Ha/tractor and 774% in Ha/harvester). 1970 mechanization figures for our study area (2.5 Ha/H.P. and 427 Ha/harvester) were even higher than means for the whole province (2.9 and 446 respectively — the lower the figure, the higher the mechanization). Values from 1979 also show that a noticeable development has taken place during the last years: 2.2 Ha/H.P. and 261 Ha/harvester (Sanz Jarque et al. 1979).

As a consequence of recent mechanization and use of fertilizers, yields increased from mean figures for 1955-60 of 680 kg/Ha and 690 kg/Ha for wheat and barley, respectively, to 1025 kg/Ha and 1410 kg/Ha for 1961-70, and to 2870 kg/Ha and 3280 kg/Ha for 1979.

Data mentioned above indicate that Zaragoza province, and especially the area studied, were among the most important cereal farming zones in Spain, and that a substantial increase in waste grain during sowing and after harvesting has taken place during the last few decades. Such circumstances have provided the food resources necessary to permit staging and overwintering of large populations of certain granivorous species capable of exploiting agricultural resources.

Food Availability and Field Use by Staging Cranes

The food consumed by the cranes consists mainly of cereal grain that is obtained from stubble fields and sown ground. The relative surface of stubble fields, plowed ground and sown ground, as well as their seasonal variation in the study area, is shown in *Table 1*. Data were compiled by interviewing the farmers. The proportion of native grasslands and other uncultivated grounds was measured by making a transect of 37km through the area. It was found that one month after sowing had taken place, grain was no longer available for the cranes, since the plants had already begun to grow substantially.

At the beginning of the winter season the bulk of the terrain is stubble. Farmers begin to work a large part of the land during the fall, taking advantage of the autumnal rains. Fall tillage causes a rapid loss of food availability, even though it is partly compensated by the subsequent sowing of long cycle grain, mainly winter wheat. A second peak in the food availability occurs with the sowing of short cycle cereals, mainly barley in February. Thus, during the occupation period the food availability (stubble fields plus useable sown ground) reaches two peaks, in the fall and spring, which coincide exactly with the postnuptial and prenuptial migration periods, respectively (Alonso et al. in prep.). During the 1981-82 winter season, the availability of stubble fields and the amount of waste cereal grain was higher, and extended for a longer period, than usual. This was due to the dry spell which made it impossible to work the land, and impeded germination of waste grain.

In order to study the utilization of the available food by the cranes, we surveyed the area weekly, trying to locate all flocks. We recorded in each case the size of the flock, the proportion of birds actively feeding, and the cover type where they foraged. In order to quantify the feeding efficiency in stubble fields and sown ground, we did individual observations, during which the numbers of pecks and paces per minute were counted.

Table 1 shows the seasonal variation of crane habitat use over the course of the winter season. The general trend observed is a progressive decrease in the utilization of the stubble fields, parallel to the progression of tillage, and a simultaneous increase in the utilization of recently sown ground, which is not closely correlated with their bimodal seasonal availability pattern. The use of native grasslands was maximum in January. Plowed ground and half-grown cereal fields were almost never used as feeding sites and were not considered in the study of feeding site preference. Selection is not very pronounced, even though there is a certain preference for stubble areas and other cover types (*Fig. 4*). Selection of "others" could be due to a search for certain important food items (U.S. Fish and Wildlife Service 1981). Selection was somewhat accentuated in midwinter, when food was scarcest. The feeding efficiency of cranes is nearly the same in stubble areas and sown ground (*Table 2*).

Spatial Distribution of the Cranes in Relation to Availability and Dispersion of Food

The differences between the farming cycles of the two subareas into which the study area was divided determined that the season variation patterns of food availability were markedly different in each zone: in zone A, north of the main road, the major sowing period was in the fall, while in zone B it was in the spring. Because of this difference, the food supply in fall was approximately equal in both zones, while in February it was much higher in zone B (*Fig. 5*). Seasonal changes in the dispersion of the groups (dots in *Fig. 6*) reflect these differences in food distribution and abundance (Alonso et al., in prep.).

Table 1. Seasonal variation of the relative extents of main cover types available and their utilization by cranes, Gallocanta, 1981-82.

		Nov	Dec	Jan	Feb	Mar
Stubble	- % occurrence of cover type	46.44	27.21	(+)	(+)	0
	- % cranes observed feeding	76.11	69.05	23.07	12.73	0
Useable sown ground	- % occurrence of cover type	21.98	7.26	6.63	47.63	10.53
	- % cranes observed feeding	21.85	21.81	62.25	78.79	91.01
Others (1)	- % occurrence of cover type	4.72	4.72	4.72	4.72	4.72
	- % cranes observed feeding	2.04	9.14	14.68	8.48	8.99
Plowed ground & half-grown cereal	- % occurrence of cover type	26.86	60.81	88.65	47.65	84.75
	- % cranes observed feeding	∼0	∼0	∼0	∼0	∼0
Total number of cranes observed feeding		880	24,980	19,632	21,165	8892

(1) Mainly natural vegetation of lake edges and roadsides.

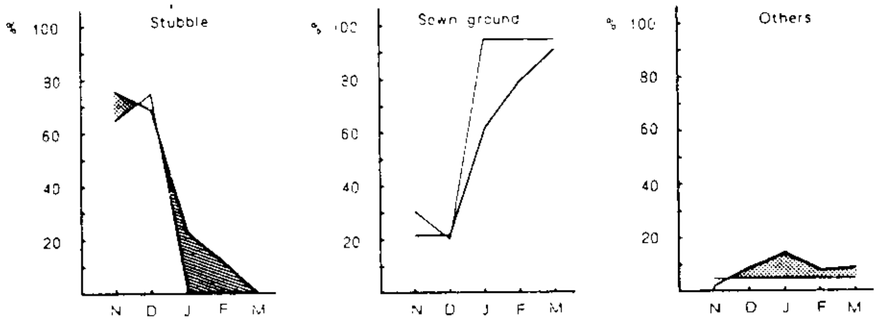

Fig. 4. Selection of the principal cover types by foraging cranes, Gallocanta 1981-82, as a relation between occurrence percentage (thin line) and utilization percentage (thick line). Only utilizable sown grounds (see text) were considered. Others = natural vegetation. Dark surface represents positive selection of each cover type.

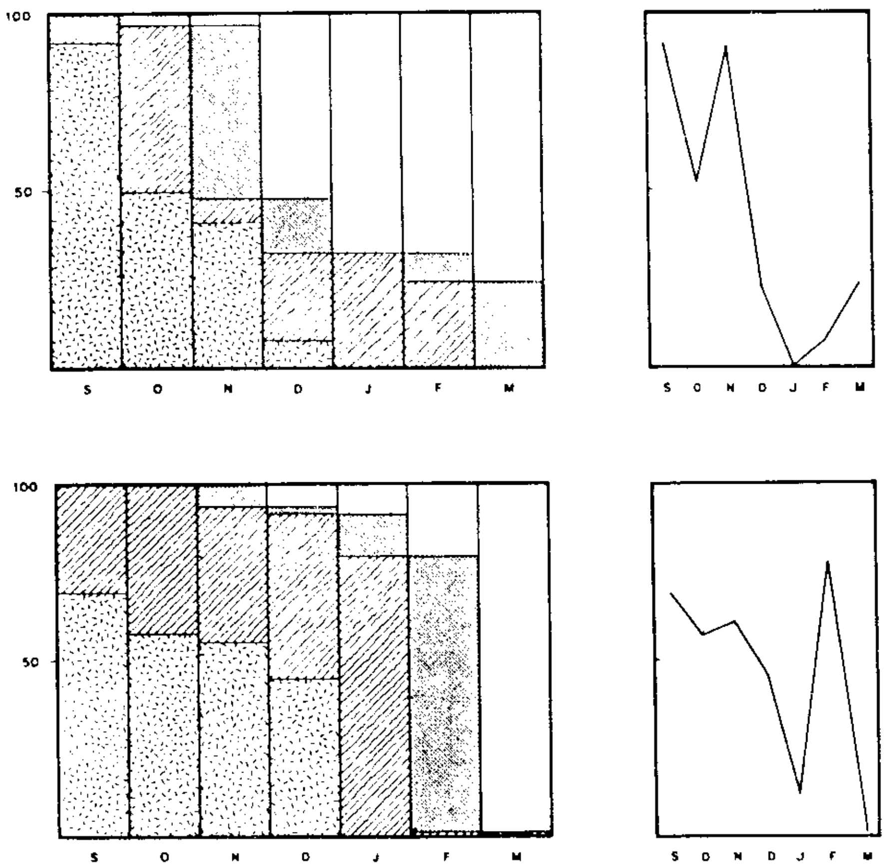

Fig. 5. Farming cycle in zone A (upper left) and zone B (lower left) (see *Fig. 6*): monthly variation of percentage of stubble, sown ground useable by cranes, sown ground not useable by cranes (see text), and plowed ground. Right side: food availabilities in both zones.

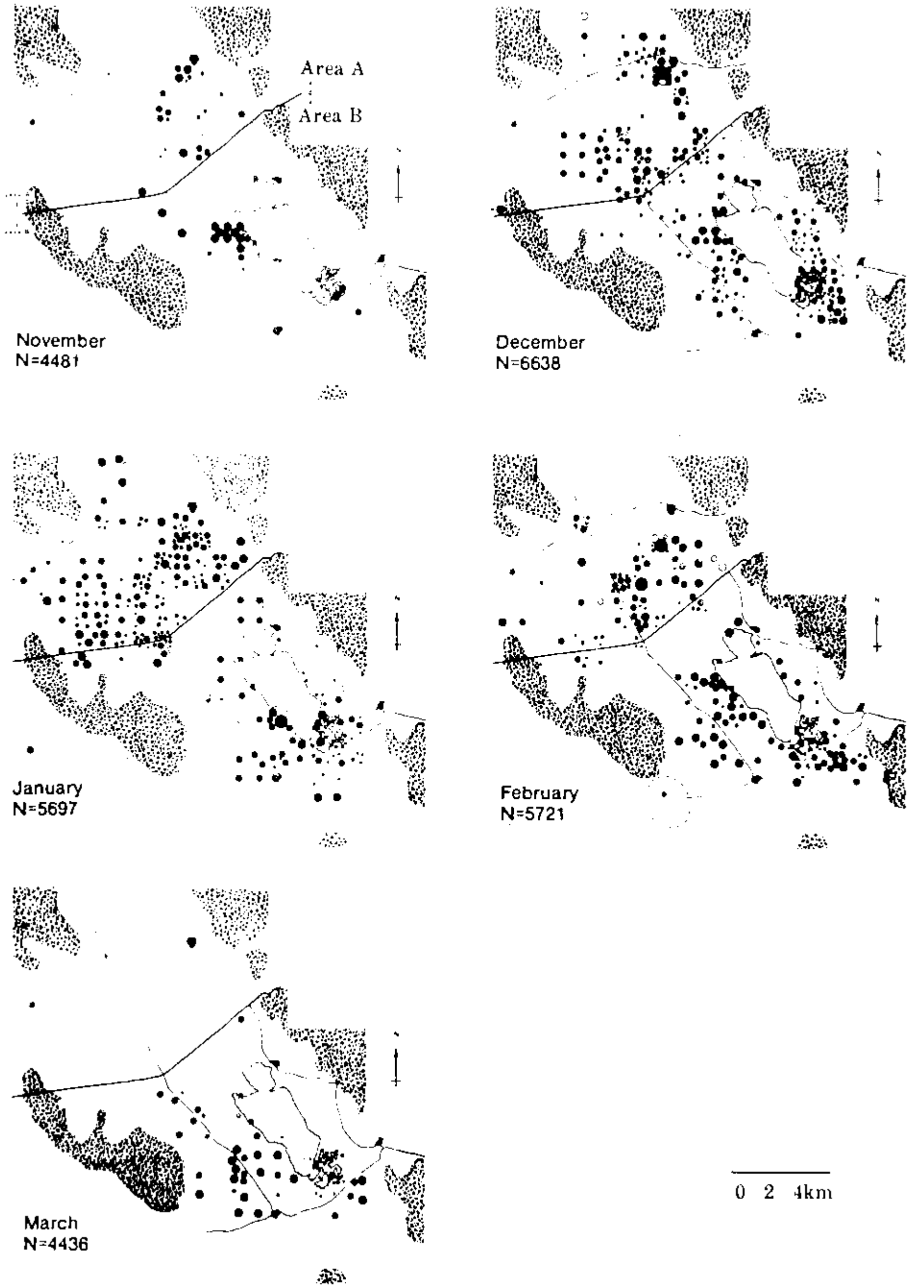

Fig. 6. Flock distribution in foraging areas. Study area is divided in two subareas A and B (November map) by the main road. Black dots are feeding groups. Open dots are drinking groups. • 1-10 birds; • 11-50 birds; ● 251-1250 birds; ● 1250 birds; * foraging groups outside the limits of the area usually surveyed. Dashed circles in November-December = sunflower stubble. R = roosts. Rectangles = percentages of crane population observed foraging on different cover types in Area A (upper right) and B (lower left). N = monthly average totals of birds.

Table 2. Feeding efficiency of adult Common Cranes in stubble and sown ground. In parenthesis, observation time and sample sizes.

	Stubble	Sown ground
pecks/minute	17.74 (29'8")	13.22 (32'44")
paces/minute	17.78 (")	17.07 (")
mean weight of the grain	0.027g (935)	0.033g (3000)
weight ingested per minute	0.479g	0.436g

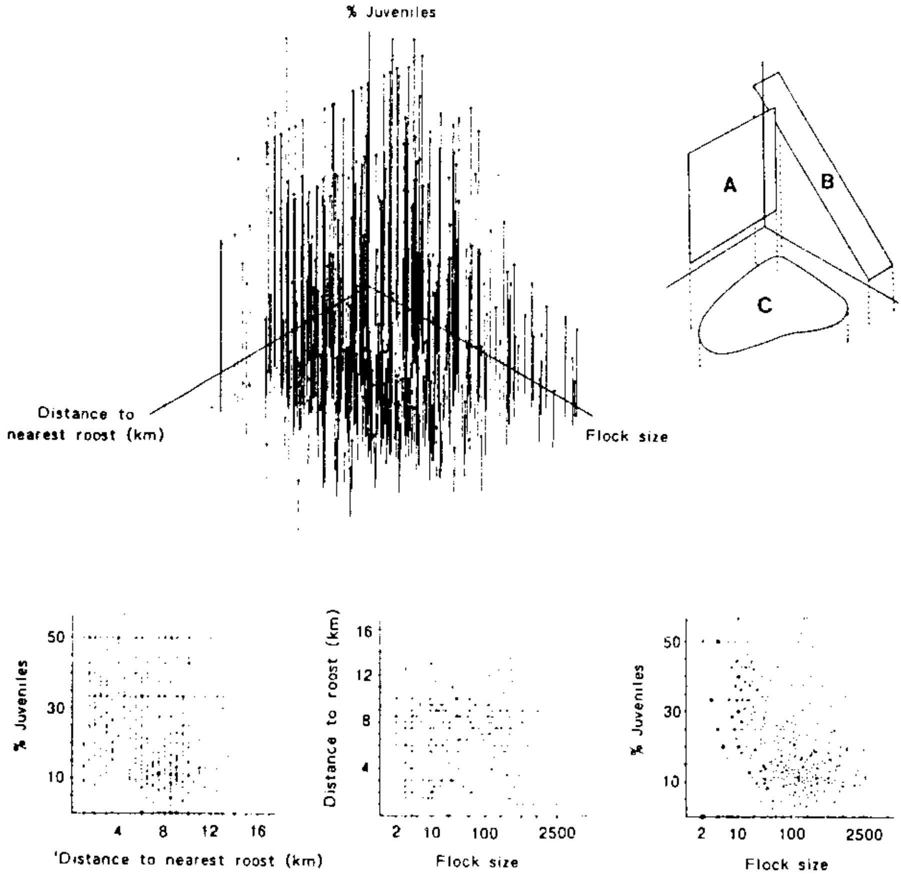

Fig. 7. Social structure: values of three variables related to flock organization in Gallocanta, 1981-82 (upper left), and schematic representation (upper right). Lower part of the figure: projections on each of the three planes considered. Flock size scale is logarithmic. Number of flocks: 411.

Social structure: relationships among some parameters

Among several variables studied in relation to the social structure and ecology of the cranes, we have selected three which we presume to be most characteristic of the wintering population: age ratio, distance to the nearest roost, and flock size. Data of 411 flocks were analyzed. The relationships between these three parameters are shown in *Fig. 7.* The

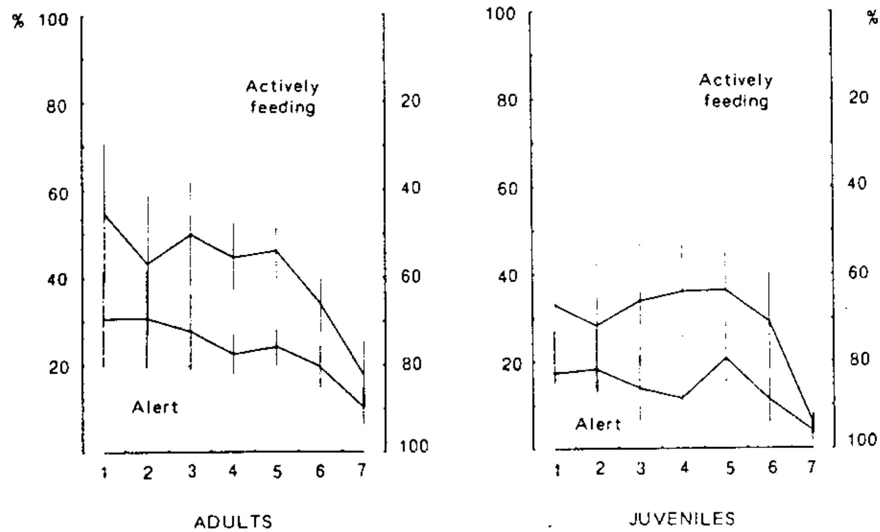

Fig. 8. Variation of the time devoted to "Alert" and "Actively feeding" in relation to flock size, both in adults and juveniles, Gallocanta, 1981-82. The scale on the right side of each panel corresponds to "Actively feeding" and that on the left to "Alert." Flock sizes: 1 = 1-4 birds; 2 = 5-12 birds; 3 = 13-36 birds; 4 = 37-108 birds; 5 = 109-324 birds; 6 = 325-972 birds; 7 = 973-2816 birds. Vertical lines: 95% confidence interval.

variables considered define three types of social organization within the population: A) Independent families or small groups mainly composed of families (approximately 2-20 cranes). These families or familiar groups may forage at variable distances from the roost (0-13km); B) Groups of variable size, from small aggregations of families to about 2500 birds. These groups remain near the roost and show age-ratios inversely related to the flock size; C) Midsized to large flocks (approximately 20-3000 birds) with a low percentage of juveniles (around 10%). These flocks fly to feeding sites located at intermediate to far distances from the roost (5-17km).

Examining the projections of the obtained values upon the three planes determined by the three axis that were considered, the following points stand out: 1) There is a clear inverse relation between the flock size and percent of juveniles; the same relation was found in the Sandhill Crane (*G. canadensis*) (Lovvorn & Kirkpatrick 1982); 2) There was an area between 4-5km from the roosts where density of groups was definitely lower than in fields less than 4km or more than 5km from roosts. Reasons for this zone of lower field use are unknown. The zone of lower use separates the last two types of social groups mentioned above (B and C).

The relation between the size of the flock and the relative time spent "actively foraging" and on "alert" posture was also studied. Both adults and juveniles devote less time to alert and more time to feeding as the flock size increases (*Fig. 8*). As a rule adults spend more time on alert than juveniles, which was also observed in the Sandhill Crane (Miller and Hatfield 1974). The noticeable rise in time dedicated to feeding in small flocks — between 5 and 12 birds — may be explained by the fact that families tend to group into small flocks to feed. In these flocks time spend on other activities — resting, preening, social interactions, etc. — diminishes, but there is no decrease of the time spend on alert. This trend was observed both in adults and juveniles considered separately. While adults tend to spend more time feeding as flock size increased, the time spent by the young feeding tends to diminish slightly in intermediate sized flocks. This may be one of the reasons why the families with offspring tend to separate themselves from the large flocks (Prevett and

MacInnes 1980). The longer time spent on alert in both age classes, but especially in juveniles, in intermediate sized flocks (109-324 birds) could be related to some kind of social function within flocks of this size.

Daily Routine

Cranes habitually use two areas of the lake as roosts, one more regularly, depending on the number of birds present, their daily dispersion, and other factors. The birds leave the roost between 0630 and 0700, depending on the amount of daylight. As a general rule they fly directly to the foraging sites, which may be as far away as 17km. Very few birds stop near the roost for a while in what Wheeler and Lewis (1972) called the "secondary roost." Most of the time spent at the foraging sites is devoted to feeding, adults 56.8% and juveniles 70.4%. Two periods of greater feeding intensity occur, one during early morning, the other in late afternoon. As day length increases, the feeding rate tends to diminish during midday (*Fig. 9*) (Alonso et al., in prep.).

The daily variation of flock size was studied in 571 flocks (*Fig. 10*). Flock size increases until the afternoon (1400-1500). Between 1500 and 1600, the mean flock size diminishes considerably, and later it grows drastically until entering the roost. Before 1000 no groups larger than 973 birds occurred. Large groups are recorded until 1500. Between 1500 and 1600 they disappear completely, but later they occur regularly (see small bars in *Fig. 10*). The biomodal size distribution occurring in the 1600-1700 interval, with a lower frequency of the average size class (mean flock size over 578 flocks=160 cranes) suggests that the dispersion taking place in the preceding time interval, as indicated by a decline in the main flock size in that interval, results in two types of aggregations: some small and some large to very large.

Analyzing the hourly variation of the various size of flocks separately, we observed that the frequency of small flocks progressively diminishes throughout the day, occurrences of midsized flocks remains constant, and the frequency of large flocks shows progressive increase, extraordinarily pronounced in the last hours (*Fig. 10*). In the large flocks, the birds spend most of their time feeding intensively (compare *Figs. 8 and 9*) in specific sites. Around sunset, cranes fly directly, in midsized or large flocks, to zones near the roost, and there they habitually form one or a few "Preroost gatherings," perhaps analogous to what Wheeler and Lewis (1972) and Lewis (1978) called "secondary roosts." The flight to the roost generally occurs suddenly and "en masse." The roost is always located in shallow water at the edge of the lake.

Impact on the Environment

We have tried to measure the impact on the environment by studying the relation between the amount of grain consumed by the cranes and the total quantity available (*Table 3*). Availability of waste grain in stubble fields was ascertained by randomly selecting 5 fields. In each field, 5 plots (0.25m^2) were randomly sampled for availability of waste grain. The mean value obtained was 37.4 grains per unit, which is equal to 40.4kg/Ha. The quantity of available grain in sown ground and the relative surfaces of stubble field/sown ground for each month were determined from data received from the farmers. The dry weight of one individual grain was 0.027g in stubble and 0.033g in sown ground.

We calculated the individual energy requirements for one crane both through observation of the quantity of grain ingested per time unit and with Gavrilov and Dolnik's (1977) equation. Values obtained were 161.05g/day and 129.07g/day respectively (Alonso et al., in prep.). The total population energy requirement was obtained by multiplying the individual value by the mean number of cranes per day for each month. The winter population in Gallocanta consumed 1.32-1.59% of the total grain-biomass available in 1981-82. Since food availability was minimal in January, impact was greatest in that month (6.69%). Thus, food availability could act during midwinter as a limiting factor of the quantity of cranes that the ecosystem can support. The feeding pressure values found in

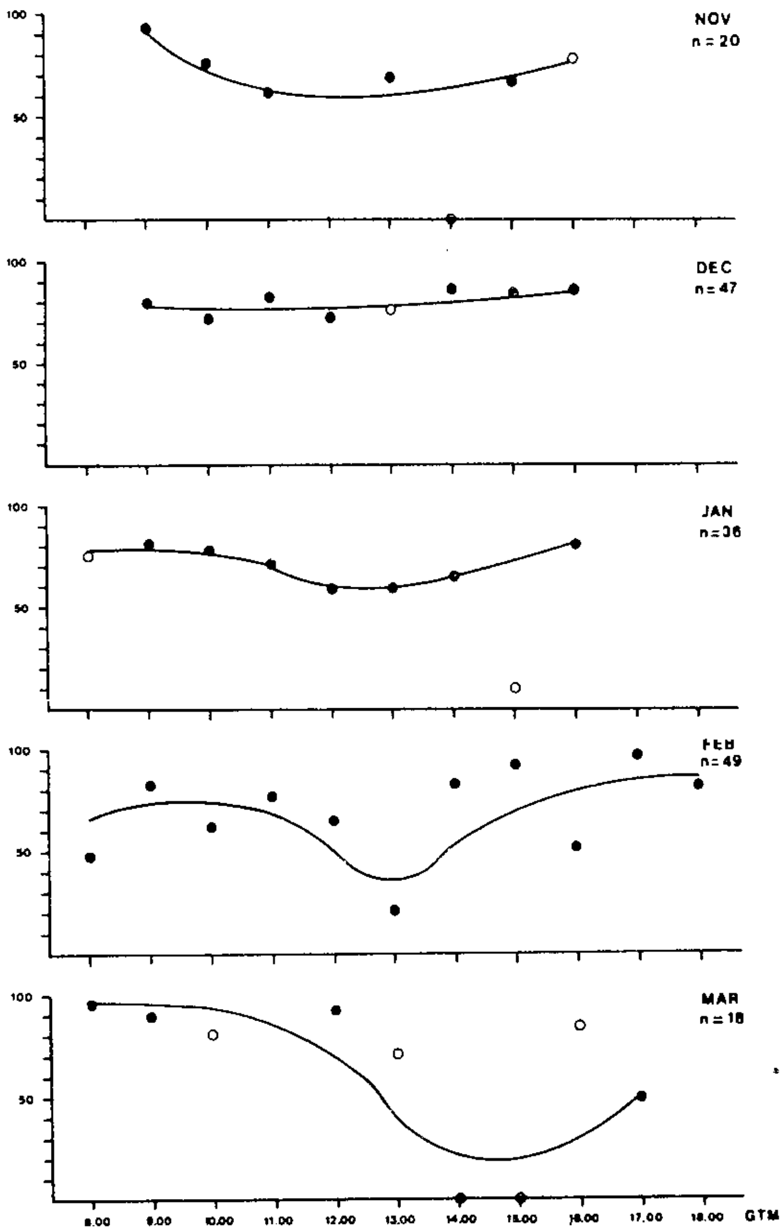

Fig. 9. Daily variation of the feeding rate. Dots represent average percentage of cranes actively feeding in foraging flocks. Open circles = one flock only. n = number of flocks. Curves fitted by eye.

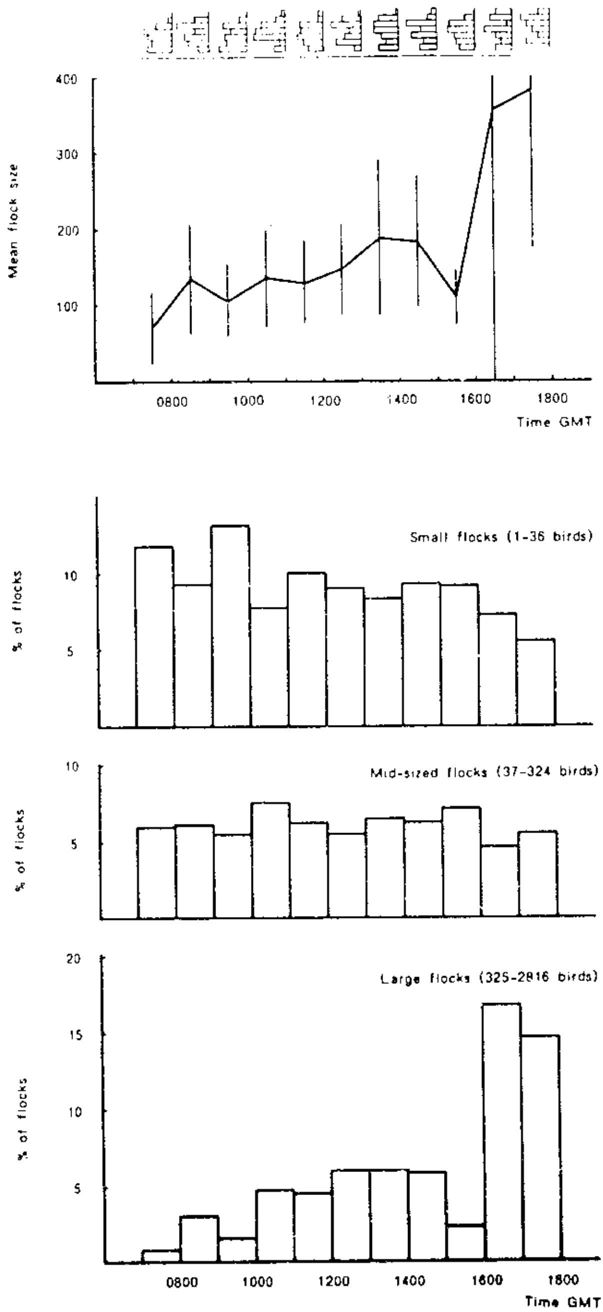

Fig. 10. Daily variation of the mean flock size with 95% confidence interval (graph, upper part) and distribution of frequencies of each flock size class in each 1 hour interval (small bars in upper part of the figure: flock size classes are the same as in *Fig. 8*). Bars in the lower part of the figure represent variation of the percentages of each flock size category. Number of flocks: 571.

Table 3. Cereal food availability and consumption, Gallocanta, 1981-82 (surface studied=40000ha)

		Nov	Dec	Jan	Feb	Mar	TOTAL
Available cereal food (Tm grain)	in stubble	787.4	416.4	~0	~0	0	787.4
	in sown ground	1360.5	450.2	411.2	2953.2	652.8	5827.9
Total available		2147.9	866.6	411.2	2953.2	652.8	6615.3
Total consumed(1)	minimum (1)	8.7	25.7	22.0	22.1	8.7	87.2
	% (2)	(0.40)	(2.96)	(5.35)	(0.75)	(1.33)	(1.32)
	maximum (1)	10.8	30.0	27.5	26.6	10.8	105.7
	% (2)	(0.50)	(3.46)	(6.69)	(0.90)	(1.65)	(1.59)

(1) The minimum figure was calculated using Gavrilov and Dolnik's (1977) metabolic equation for *G. grus*, and the maximum one through field observation of the amount consumed per time unit (Alonso et al., in prep).

(2) Percentage consumed of total available.

Table 4. Annual mortality rates and number of cranes that survive each year during the "subadult" period, assuming that mortality is 0 from the 5th year on, and considering all birds less than 5 years old as subadults.

Age (1)	% mortality	cranes survived
December (year 0)	-	2176 (3)
February (year 0)	6.68 (2)	2031 (3)
May (1st year)	35.33	1883
May (2nd year)	26.50	1384
May (3rd year)	19.88	1108
May (4th year)	13.25	961
May (5th year)	6.63	897
May (6th year)	0	897

(1) We count life years from the month in which clutch laying takes place (May).

(2) This figure represents the mortality rate measured between December and February (see text).

(3) Figures were calculated from age ratios observed in each month.

Gallocanta are much lower than those mentioned for the Platte River (U.S. Fish and Wildlife Service 1981).

ANNUAL RECRUITMENT AND OTHER DEMOGRAPHICAL ASPECTS

As almost the entire wintering crane population utilizes the study area during both migratory periods, it is possible to record the age ratio two times per year. The reduction in percentage of juveniles between fall and spring may serve as winter mortality index for that age class, if we assume that the mortality rate of the adults is equal to zero. The figures obtained during the 1981-82 season, as well as the mean date to which they refer, December 12 and February 19 respectively, were obtained by proportionately evaluating numbers of birds present in the area during both periods. Annual mortality rate for juveniles obtained was 33.35% (*Table 4*) We assume that the mortality rate decreases lineally from this value to 0 in five years old birds. This way we calculated the numbers of "immature" birds hatched during year 0 that will survive in each of the following years (*Table 4*). Thus, the preadult fraction of the population between 1 and 5 years old was estimated to be around 5336 cranes (35.57% of the total population). Comparison of productivity data with those of Glutz et al., (1973) suggests that the number of adults in the population must be larger and therefore the age of first breeding must be prior to the generally accepted age of 5 years (Veiga et al., in prep.). Productivity expressed by the age-ratio measured during the fall period, has fluctuated between 11.85% in 1982 and 14.51% in 1981. This last figure differs significantly from values in 1979 and 1982. Moreover, in 1981 the mean number of young per successful breeding pair was significantly higher than in 1982 (*Table 5*).

DISTRIBUTION PATTERN OF THE DIFFERENT AGE-CLASSES IN IBERIA

All Iberian wintering areas can be grouped in one of the three types shown in *Fig. 11*. Some sites are typical wintering localities (*Fig. 11A*), others are staging areas (*Fig. 11C*), and a third type is comprised of those sites in which the occupation is not constant, showing apparently irregular movements of birds between them throughout the winter (*Fig. 11B*). We distinguish sites of early and late occupation (*Fig. 11B1* and *11B2* respectively). Sites of

Table 5. Annual recruitment values (both as percentage of juveniles and mean number of juveniles per successful adult pair measured at Gallocanta lake during October-December) for the western population of the Common Crane in 1979, 1981, and 1982.

	1979 (1)	1981	1982
Percentage of juveniles	12.57 (2)	14.51 (2)	11.85 (2)
Number of birds aged	6201	12445	16499
Mean number of juveniles per identified family group	1.42 (3)	1.54 (3)	1.29 (3)
Number of families identified	45	41	338

(1) From Fernandez Cruz et al. (1981)

(2) Differences in juvenile percentages were highly significant between 1981 and 1982 ($t=6.66$; $P \;\; 0.001$) and between 1979 and 1981 ($t=3.61$; $P \;\; 0.01$). There were no significant differences between 1979 and 1982 figures ($t=1.48$; $P \;\; 0.05$).

(3) Differences in mean number of juveniles per identified family group were significant only between 1981 and 1982 ($x^2=8.62$; $p \;\; 0.01$), but not between 1979 and 1982 ($x^2=2.68$; $p \;\; 0.05$) and between 1979 and 1981 ($x^2=0.71$; $p \;\; 0.05$).

type A are more numerous (22) than sites of types B (14) and C (4), and the mean number of cranes that occupy typical wintering sites (221.6) is smaller than the mean quantity in types B (354.1) and C (847.5) (t_{AB}=1.69; P > 0.05; t_{AC}=4.48; P < 0.01; t_{BC}=2.54; P < 0.05). Moreover, mean age-ratio in typical wintering localities is significantly higher than that in types B and C (t=6.08; P < 0.01 and t=6.77; P < 0.01, respectively).

DISCUSSION

Factors Influencing Numbers and Distribution

Among several factors analyzed as possible reasons for recent increase in number of cranes using Gallocanta as a staging area, higher food availability seems to be the most important one. The increase in the amount of food has been a direct consequence of the mechanization and intensive cultivation during the last decades. Similar findings have been stated for the Sandhill Cranes staging along the Platte River (U.S. Fish and Wildlife Service 1981). Geographic location of the area, presence of a shallow lake surrounded by flat fields, absence of woody vegetation and restricted hunting from 1973 have surely had an influence (Alonso et al., in prep.). Perhaps the deterioration of other staging areas along the migration route of the species has also contributed.

Current crane concentrations at Gallocanta are even larger than those reported for Müritz, Rügen, Oder Valley and Hornborgasjön (Makatsh, 1970; Glutz et al., 1973). Utilization of agricultural resources by cranes has been reported for different species and geographic zones: i.e. remainders after harvesting potato fields in Hornborgasjön (Glutz et al., 1973), cereal in North Dakota and Saskatchewan (Madsen, 1967), corn stubble in the Platte River valley (U.S. Fish and Wildlife Service 1981) and in Hungary (Makatsh 1970), corn and soybean in Indiana (Lovvorn and Kirkpatrick 1982), etc.

Coincidence between the farming cycle and the phenology of migration in our study area and high waste cereal availability due to agricultural mechanization provide the necessary food supply for the staging crane population during several weeks. Interannual differences in the tillage timing could be responsible for the changes observed between different years in the numbers of cranes remaining there between both migratory peaks. Moreover, in outline we observed a relation between location and foraging flocks and areas with higher food supply. The site fidelity stated by Lovvorn and Kirkpatrick (1982) as the main cause for the flock distribution was also observed in our study area. Nevertheless our research findings indicate that site fidelity may in fact be conditioned by the above mentioned food abundance.

Social Structure and Daily routine at Gallocanta

Family cohesion lasts for the entire season in several crane species, even though disappearance of familiar bonds before prenuptial migration has been stated for the Sandhill Cranes (Nesbitt and Archibald 1981) and for the Common Cranes (Alonso et al., 1983). Enhanced feeding time for juveniles seems to favor family cohesion (Prevett and MacInnes 1980; present study). On the contrary, familiar groups are clearly disadvantageous for adult birds, as time devoted to feeding decreases noticably in such groups. Therefore, adults without offspring and nonbreeders tend to aggregate in sizeable flocks that enable them to spend more time feeding. Those flocks generally forage at greater distances from the roost and wander more.

Mean flock size increases regularly until midday, as has been observed for the Sandhill Crane (Miller and Stephen 1966; Madsen 1967; U.S. Fish and Wildlife Service 1981, Faanes and Frank 1982). The wide dispersion of small flocks with high feeding activity in the morning, the progressive aggregation with a concomitant decrease in the feeding rate until midday, and a second dispersion of the groups and later sizeable flocking and intensive feeding in the afternoon all suggest the existence of an initial search for suitable feeding areas and a subsequent "information transfer," followed by a second feeding period population was spread out over a wide area in central and SW Iberia. Wintering aggregation were typically small, with mean numbers of about 100 birds, and the principal feeding habitat was open oakwood with dispersed cereal farms. Cranes roosted near ponds or in open zones near the feeding sites. There are even records of breeding pairs in a marshy area in Laguna de la Janda in 1954. As a consequence of drainage of the wetland in the 1950s, cranes no longer nest there. The migration corridor was ample and birds stopped briefly at several localities in north and NE Spain (Valverde 1952, Bernis 1966). Later on, felling of wide oakwood areas, and agricultural changes probably caused the aggregation of a number of small groups into fewer suitable areas with 500-1500 birds each (Pérez Chiscano and Fernández Cruz 1971). This concentration process has continued until the present time (Fernández Cruz et al. 1981). The features of the Laguna de Gallocanta area also permitted concentration during migration. As a consequence, increasingly large numbers of cranes began to stage there in fall and spring.

Staging periods lengthened, and during the last 10 years more and more birds have remained in Gallocanta throughout the winter (*Fig. 12B*). In certain years with favorable conditions, high cereal availability on the ground in Gallocanta, poor acorn crop in SW Iberia, mild winter or drought, numbers of cranes overwintering in Gallocanta are very high: 5000-6000 individuals in January 1981-82 (*Fig. 12C*). Such an increase in the crane numbers in Gallocanta is surely correlated with the decrease in numbers in a few areas with large concentrations in SW Iberia while occupation of traditional localities with smaller wintering numbers has remained stable. The distribution during the 1981-82 winter was probably somewhat abnormal; *Fig. 12C* may represent an extreme situation. Nevertheless, the mean occupation of Laguna de Gallocanta (number of cranes per day) is still very important (*Fig. 2*), with almost 100% of the population migrating through the area. A similar increase in numbers using a staging area due to recent agricultural changes was documented for the Sandhill Crane on the Colorado River near Parker, Arizona (Lewis 1977).

The facts discussed above suggest that habitat alterations due to human activities are influencing the distribution pattern of the species. Cranes respond to environmental changes by forming larger aggregations, and birds without offspring are the first to form such groups while family groups exhibit higher site-fidelity.

MANAGEMENT NEEDS OF THE COMMON CRANE POPULATION WINTERING IN IBERIA

We still know little about certain important aspects of the winter ecology of the Common Crane in Iberia. There are many unanswered questions concerning habitat requirements and adaptability to habitat changes in the "traditional" wintering areas of SW Spain. In particular, there is a need to know how much the gradual change in the cranes' diet, from a variety of natural food items to cereal, could affect the species, especially when chemical treatment of the seeds and abuse of fertilizers and toxic products is increasing dramatically. It is also necessary to monitor the status of the wintering population periodically, in order to obtain data on annual recruitment and to foresee short term trends of the species. Banding programs at staging and wintering areas should be carried out to determine mortality rates and the age structure of the population. Data on taxonomy, age and sex determination, effects of pesticides, and a wide variety of other important subjects related to management could also be obtained. In addition, banding would help define the various migratory units in the Western Palearctic.

Provisional results of crane investigations conducted in Spain suggest that increased felling of ilex-oaks (*Quercus rotundifolia*)in SW Iberia and general agricultural development during the last few decades have induced important changes in the migration and wintering pattern of the population. Agricultural changes have probably caused the aggregation of a number of small groups in fewer suitable areas. This concentration process has continued until the present time, and today almost 100% of the population migrates through Laguna de Gallocanta, which represents the major staging area in Iberia, and probably in Europe. Such crowding at one locality implies many well-known risks. Cranes are probably able to overcome the natural course of epizootic outbreaks, but a combination of natural and artificial environmental stresses could cause a serious threat with little prospect for control. In particular, potential effects of agricultural nutrients and pesticides at major staging areas should be urgently investigated, and use of such products should be controlled by Government Agencies. If present farming practices change, the likelihood of food shortages at certain localities increases, and, although high mobility is one of the characteristics of large wintering aggregations, shifts into unknown areas could become an important mortality factor or, at least, an additional danger.

In view of the above, we believe that one of the following two management criteria should be considered:

1) To warrant absolute and perpetual protection of a wide number of traditional wintering localities by stopping habitat deterioration, agricultural progress and industrialization, a method that seems rather unpractical and unrealizable, or:

2) To manage a few (5-6) major areas with demonstrated capacity to receive the whole population. This should not be done without previously studying habitat quality and quantity in relation to the species ecological needs at every wintering area. Laguna de Gallocanta should be ragarded as the principal staging area in Iberia.

Management of wintering zones cannot be undertaken without consideration of requirements during the rest of the arrival cycle. Conservation of several suitable staging areas along the migration route is necessary.

In summary, we suggest the following urgent management measures:

1) Study of the population dynamics by annual recruitment surveys and winter censuses of the population every 3 years.
2) Establishment of 5-6 crane reserves, including Laguna de Gallocanta in which land-use practices could be monitored to ensure protection of the crane population.
3) Investigation of the long-term effects on granivorous species of pesticides and fertilizers currently used in agriculture.

RECOMMENDATIONS TO MEET MANAGEMENT NEEDS AT LAGUNA DE GALLOCANTA

1) Protection of Gallocanta basin, classified under category B of the Ramsar Convention, is necessary to protect the staging and wintering site of many birds, especially cranes and ducks.

2) Optimal natural water level of the lake should be maintained through prohibiting or regulating water removal for agricultural purposes.

3) Prevention of possible sources of water contamination is urgent.

4) Cereal crops constitute the principal energy source for cranes and other species. Therefore, current land use practices should be maintained, and other crops (sunflower, sugar-beet, etc.) or field usages regulated.

5) Destroyed habitat at the lake edges should be restored, and natural grasslands and meadows preserved, to ensure availability of certain important additional nutrients for cranes (invertebrates, roots, minerals, etc.).

6) Important causes of disturbance, especially human interference, at roosts and feeding sites should be investigated and regulated.

7) Farmers should be compensated adequately for the local crop depredation.

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WINTERING COMMON CRANE IN IRAN

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ABSTRACT

Since 1971, the population of wintering Common Cranes (*Grus grus*) censused in Iran has fluctuated from approximately 250 to nearly 1900. This range may reflect illegal hunting, now controlled, and incomplete censuses. The birds are fully protected in Iran and the Department of the Environment patrols staging and wintering sites.

INTRODUCTION

Since 1976, the Iran Department of the Environment and the International Crane Foundation have been studying winter flocks of Common Cranes in Iran, with the hope of using these birds as foster parents for Siberian Cranes (*Grus leucogeranus*). In addition to these species, the Demoiselle Crane (*Anthropoides virgo*) is found in Iran.

The Common Crane occurs as a wintering bird, mostly on irrigated land adjacent wetlands of northeast, central, southwestern Iran (*Fig. 1*).

After a two decade disappearance a small number of Siberian Crane were found at the central southern part of the Caspian in 1978. Since then, 4-12 have been seen at the same place (Feraydon-Kenar) in midwinter every year. The Demoiselle Crane is found in very small numbers on the Turkaman steppes southeast of the Caspian and in the central southern part of Fars province.

Besides the studies on distribution of the Common Crane, the Department of the Environment has investigated the habitat requirements and food preferences of the Siberian Crane. The Department used the drug Alpha-chloralose to capture and mark 192 Common Cranes with green, orange and red tags during the winters of 1975-76 to 1977-78 (*Table 1*). In following years, the studies were confined to censuses throughout Iran.

Table 1. Number of tagged Cranes and the years of studies.

Areas	Wing Tag Colour	Number	Year
Pabrishan	Orange-Green	72	1975-76
Desbt-e-Arjan	Orange	112	1976-77
Desbt-e-Arjan	Red	8	1977-78

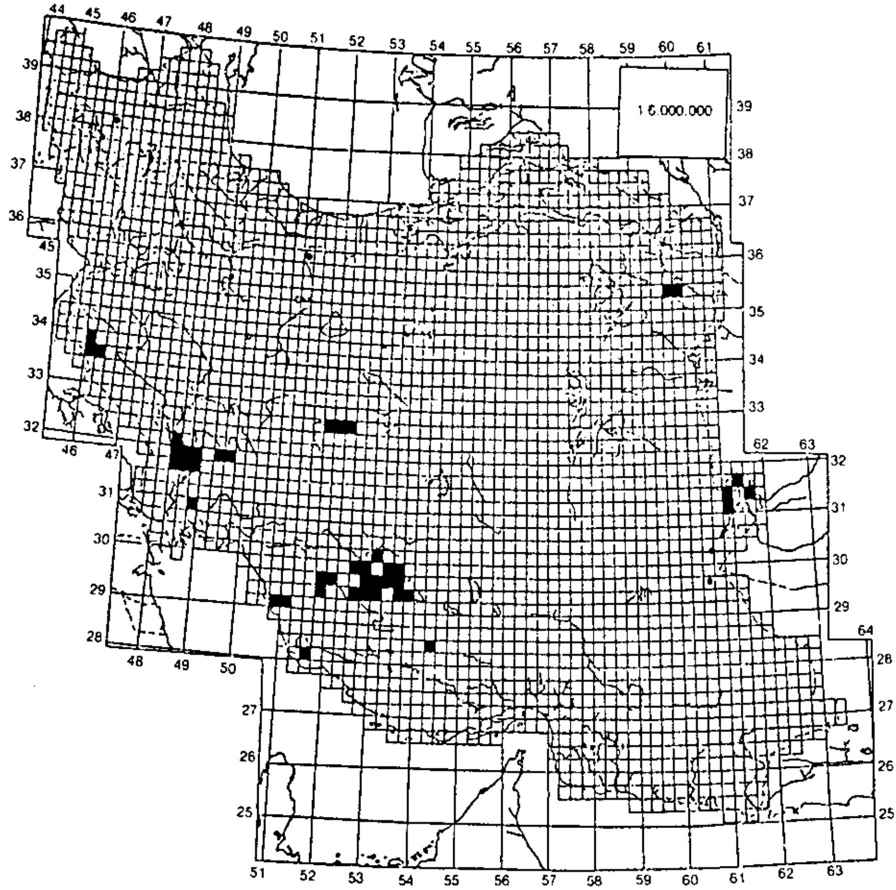

Fig. 1. Distribution of Common Crane in Iran. Notes: ■ Wintering record • records of summering (non breeders)

DISCUSSION

In the southern parts of Iran the migration of Common Cranes is conspicuous during spring and fall. Most of the migrant cranes in Iran probably came from the northern part of the USSR. They first arrive in October, landing at the wetlands at high elevations, especially in the lakes at 2000-2900m. After two or three weeks, when the lakes freeze and the winter rains begin in November or December, the cranes scatter in smaller groups in warmer areas to the south. To illustrate this pattern, cranes arrive at Lake Kaftar, 2300m, in late October in flocks of about 1000 to 1200. In mid-November, they leave the lake in smaller flocks of 200-300 and settle for the winter at places such as Lake Pahrishan, the Gulf coast, and other wetlands or arable lands south of Fars province.

Although the crane censuses in Iran are not complete, *Table 1* shows that in four regions between 1975 and 1977 the population dropped. Reasons for this decline may include habitat disturbance and illegal hunting. Habitat disturbance, especially draining wetlands adjacent to lakes, changing wetlands suitable for cranes to agricultural lands, and the use of scarecrows all have an adverse effect on the cranes. Illegal hunting of cranes,

Table 2. Mid winter censuses of Common Crane (*Grus grus*) in Iran 1972-1977.

Locality		Winter 1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
Tayebad area	59 60N 35 36E	22	46	-*	274	-*	-*
Isfahan area	52 53N 32 33E	-	30	13	51	-*	-*
Ilam area	46 47N 33 34E	206	250	-	-	-*	-*
Karun, Dez	45 46N 33 34E	1315	385	711	299	-*	-*
Izeh Lake	46 47N 34 35E	-	-	-	400	-*	-*
Heleh & Mond river	54 55N 28 29E	-	-	120	96	-*	-*
Dasht-e-Arjan	49 50N 31 32E	32	19	75	2	183	138
Lake Parishan	49 50N 31 32E	3	182	275	275	17	27
Bakhtegan	48 49N 32 33E	9	548	375	541	127	158
Lake Kaftar	49 50N 33 34E	-*	-*	-*	-*	-*	-*
Baiza, Kur Valley	48 49N 32 33E	-	5	14	68	-	-
Hamoun Lake	61 62N 31 32E	15	145	25	450	84	130
Total		1602	1610	1608	2456	411	453

Localities with the Department of the Environment reserve.
* No census undertaken.

Table 3. Mid winter censuses of Common Crane (*Grus grus*) in Iran 1978-1983.

Locality		1979-80	1980-81	1981-82	1982-83
Dasht-e-Arjan	49 50N 31 32E	158	128	5	146
Pahrishan lake	49 50N 31 32E	16	27	238	31
Kaftar lake	49 50N 33 34E	-*	-*	1200	620
Bakhtegan lake	48 49N 32 33E	158	-	-	247
Lar area	53 54N 27 28E	-*	15	-	164
Karun & Dez	45 46N 33 34E	-*	-*	-*	148
Hamoun lake	61 62N 31 32E	378	-	450	400
Total		710	160	1893	1756

-* No census was taken.
Localities with the Department of the Environment.

together with the difficulty of controlling areas in unprotected regions are other problems. All the protected regions in Iran, are patrolled by game guards; habitat destruction or illegal hunting is forbidden throughout the reserves.

The increase of the crane populations since 1978, shown in *Fig. 1*, reflects more accurate censuses and better protection. The game guards, for example, were able to patrol the areas and prevent crane hunting. Greater efforts have been made with local people to encourage them to protect wetlands and to foster an awareness about cranes.

The Department of the Environment is the only governmental organization responsible for research projects concerning endangered birds in Iran; the ornithology unit of the Department has established a research project on habitat improvement for cranes. All species of cranes are now recognized as fully protected birds and hunting is forbidden.

CHAPTER IV

EDITORS' INTRODUCTION: AFRICAN CRANES

In prehistoric times the Crowned Cranes, genus *Balearica*, were found all across the northern continents. But with the advance of the ice sheets these cold-sensitive cranes survived only in Africa, where tropical conditions were maintained throughout the Pliocene and Pleistocene.

The classification of the two forms of Crowned Cranes has been controversial. Johnsgard (1983, Cranes of The World, Indiana University Press) lumped them as a single species. The report by Ingold in this volume, however, indicates that there are fundamental biochemical differences between the Black Crowned Crane (*Balearica pavonina*), and the Grey Crowned Crane (*Balearica regulorum*), and recommends that they be considered as separate species. This conclusion is supported by behavioral and morphological studies.

Until recently the Black Crowned Crane ranged widely, with tens of thousands of individuals breeding across the grasslands of West Africa from Senegal to Sudan. Their range has now been fragmented and their numbers severely depleted, perhaps by recent desertification in the north and undoubtedly from increasing pressure from human populations. Nigeria was recently a stronghold for the species, but cranes have now been nearly extirpated there due to hunting, pesticide poisoning, and drainage of wetlands.

The Wattled Crane is Africa's most endangered crane. One population inhabits the western highlands of Ethiopia; little is known about its status. Central Zambia's Kafue Flats contain perhaps half of the world population, and scattered pairs are nesting on wetlands in Angola, Namibia, Zimbabwe, Malawi, Mozambique, Botswana, and the Republic of South Africa. Perhaps fewer than 7000 Wattled Cranes survive. Unlike the Crowned Cranes that nest during the rainy season in temporary wetlands, the Wattled Cranes prefer to nest on permanent wetlands at the end of the rainy season. Many of these wetlands have been drained or flooded and the Wattled Cranes displaced.

Although cranes and wetlands in south Asia are reduced to pitifully small remnants, Africa still supports large crane populations at enormous wetlands such as the Sudd of Sudan, the Kafue Flats of Zambia, and the Okavango Delta of Botswana. But pressures from mankind are enormous in Africa, and in many areas wildlife is simply considered a food source for humans. The African cranes may ultimately be much more endangered than their current numbers indicate.

Under the direction of Dr. Emil Urban (Department of Biology, Augusta College, Augusta, Georgia, 30910, USA) a Working Group on African Cranes was formed at the International Crane Workshop and subsequently met in 1985 in Botswana. Group members receive an annual newsletter, *The Crowned Crane*, that is published by the International Crane Foundation.

THE CRANES OF AFRICA—AN OVERVIEW

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ABSTRACT

Six species of cranes, including one endemic genus, *Balearica*, occur in Africa: Black Crowned Crane (*Balearica pavonina*), Grey Crowned Crane (*B. regulorum*), Wattled Crane (*Bugeranus carunculatus*), Blue Crane (*Anthropoides paradisea*), Common Crane (*Grus grus*), and Demoiselle Crane (*Anthropoides virgo*). The last two are Palearctic winter visitors, the latter with a small breeding population in northwest Africa.

The Black Crowned and Grey Crowned Cranes are allospecies that form a superspecies. Separation at the level of species is based on recent electrophoretic data, different unison calls, different colored cheek patterns and necks, and different size throat wattle.

The status of the cranes in Africa varies. The Common, Blue, and Grey Crowned Cranes occur in Africa in large concentrations and are not endangered. The Demoiselle Crane from Eurasia also occurs in large numbers, but the resident population in northwest Africa is very small and endangered. Although 4000-6000 Wattled Cranes may occur in central and southern Africa, this species is already endangered in parts of its range and may become endangered in other parts due to development projects that are greatly altering its habitat. The status of this crane in Ethiopia is unknown. The Black Crowned Crane appears to be threatened and even endangered in parts of West Africa. Its status in the eastern part of its range is unknown.

There are several similarities or differences in the habits of African cranes. For example, the unison calls of Black and Grey Crowned Cranes are of indeterminate length, asynchronous and initiated by either sex while in other African Cranes they are of determinate length, synchronous and initiated usually by the female. The roosting behavior differs with crowned cranes roosting in trees as well as on the ground while the other African cranes roost on the ground or in water. Only Demoiselle Cranes and crowned cranes do not undergo complete molt of the flight feathers. The Wattled Crane prefers to dig for sedge tubers and rhizomes while the Demoiselle, Blue and crowned cranes pick up grain, other bits of vegetation, and small animals. All resident species undergo some local movements, which are poorly known. Demoiselle and Blue Cranes build nests without much material on the ground while the other species have more complicated structures that are built in marshes and are surrounded by water. The Wattled Crane has the lowest reproduction rate of any crane, varying from 1 to 0.13 young per year.

Despite their large size and in some instances large numbers, the cranes of Africa have not been studied in depth in recent years, and much of their biology remains to be determined. The Common and Demoiselle Cranes are particularly poorly known in Africa. The Wattled, Blue, Black Crowned and Grey Crowned Cranes are better known, although detailed studies on population density, social structure, migration, nesting success, and productivity are needed. Also needed are conservation and reestablishment of the endangered species.

INTRODUCTION

As part of the world-wide concern for the survival of endangered cranes, there has been a renewed interest in investigations on and conservation of cranes of Africa, particularly since two are endangered in parts of their range. Unfortunately, published accounts on the biology of cranes in Africa are sometimes in journals and books not easily accessible or out-of-print. Furthermore, studies on some of the cranes of Africa have been published in varying detail, while studies on others have not been done or have not been published. The aim of this paper is to bring together what has been published on cranes of Africa, emphasizing range, status, some features of general and breeding habits, and the major studies done on them.

SPECIES AND RANGES

Of the four genera and fifteen species of cranes of the world, all genera and six species occur in Africa. One genus, *Balearica*, and four species — Wattled Crane (*Bugeranus carunculatus*), Blue Crane (*Anthropoides paradisea*), Black Crowned Crane (*Balearica pavonina*) and Grey Crowned Crane (*B. regulorum*) — are endemic to Africa, while two — Common Crane (*Grus grus*) and Demoiselle Crane (*Anthropoides virgo*) — are Palearctic winter visitors. A small breeding population of the Demoiselle Crane also occurs in northwest Africa.

Of the six species, three occur only north of the equator (*Fig. 1*). The Black Crowned Crane occurs from Senegambia east to western Ethiopia. Common Crane is found in northwest and eastern Africa south to central Sudan and Ethiopia. The resident population of the Demoiselle Crane is restricted to Morocco and possibly Algeria and Tunisia, while the visitors from Eurasia are found in the Nile Valley south to about 10-11°N in Sudan and Ethiopia and west to Lake Chad. Of the remaining three species, the Wattled Crane has a disjunctive distribution, occurring in the western and southeastern highlands of Ethiopia and also in central and southern Africa. Grey Crowned Crane occurs from eastern Zaire, central Uganda, and southwestern Kenya south to southwestern Angola, northern Namibia, northern Botswana, and eastern South Africa. The Blue Crane is restricted to the very southern part of Africa in central and eastern South Africa and Namibia.

TAXONOMIC CONSIDERATIONS

The Black Crowned and Grey Crowned Cranes, (*B. pavonina* and *B. regulorum*) are allospecies that form a superspecies. Support for this treatment is based on different unison calls, different colored cheek patterns and necks, different size throat wattles and recent electrophoretic data (Archibald 1976, Ingold et al. this volume and Urban et al. 1986). Sometimes, however, *Balearica* is considered conspecific (*B. pavonina* by Peters 1934, Snow 1978, or *B. regulorum* by White 1965).

Demoiselle and Blue Cranes are closely related, but the evidence is insufficient to treat them as members of a superspecies or species-group (Snow 1978). Based on its unison call, the Wattled Crane is closest to the Siberian Crane (*Bugeranus leucogeranus*). The Wattled Crane is very similar to *Grus* and included with it by some authors (e.g. Snow 1978). Current unpublished biochemical evidence also suggests that *Bugeranus* and *Anthropoides* may not be distinct from *Grus* (J.L. Ingold, S.I. Guttman and D.R. Osborne, pers. comm.).

Wattled, Demoiselle, and Blue Cranes are monotypic species. The Common Crane is polytypic, but only one subspecies, *grus*, reaches Africa. The Black Crowned Crane has two subspecies, *pavonina* of West Africa and *ceciliae* of eastern Africa. The Grey Crowned Crane also has two subspecies, *regulorum* of southern Africa and *gibbericeps* of East Africa south to northern Zambia and northern Mozambique.

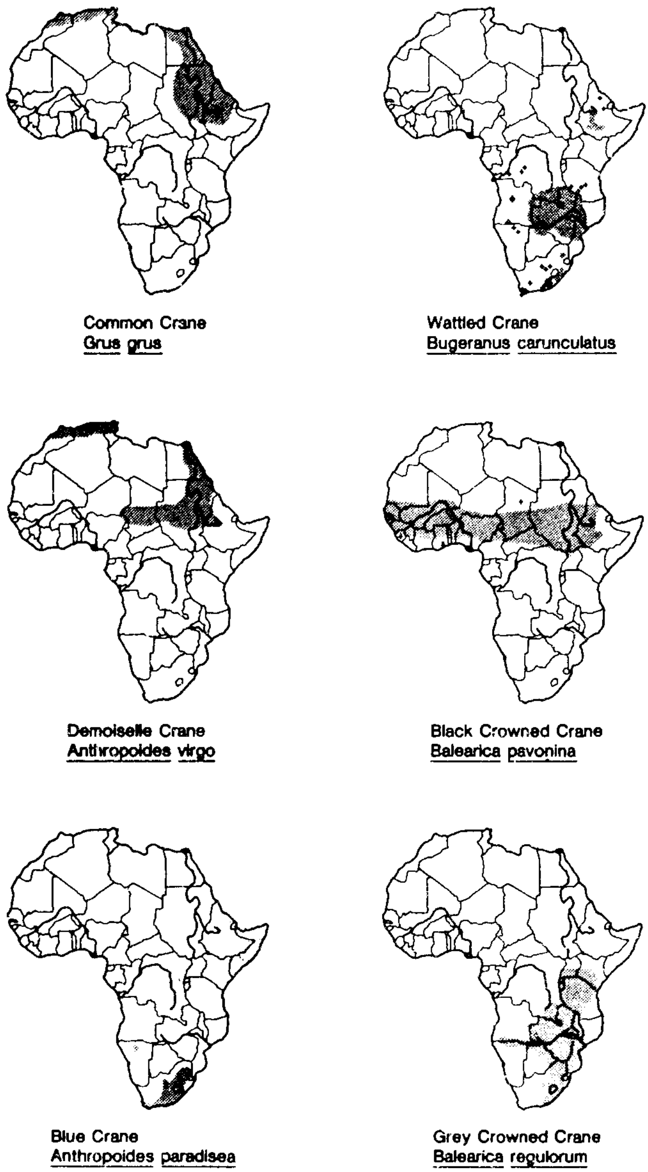

Fig. 1. Main ranges of the cranes in Africa.

STATUS

Population densities of cranes in Africa are not well documented, and figures available are only general estimates at best. The most numerous is probably the Grey Crowned Crane, which numbers many thousands. For example, in Zambia's Kafue Flats and large areas in southern Uganda with rainfall of more than 70-80cm each year, Grey Crowned Cranes have been estimated at one individual/km^2 (Dowsett & de Vos 1965, Pomeroy 1980a).

The Blue Crane is locally abundant in some parts of its range, rare in other parts, while in still other areas its status is unrecorded. Its main concentrations are in upland country of central and eastern South Africa in Eastern Cape, Orange Free State, western Transvaal, and western Natal where it is common to abundant. Its status in Lesotho, Swaziland, and Namibia are unrecorded, while in Botswana, Zimbabwe, and western South Africa it is rare or a vagrant. Its total population probably numbers many thousands and appears not to be endangered.

The Common Crane is locally abundant to common in northwest Africa, where several thousands winter in Morocco and Tunisia (Walkinshaw 1973, van der Ven 1981). Large numbers also winter in Algeria and a few do so in Libya; none are known to cross the western Sahara. It is also common to abundant in northeast Africa from Egypt south to about 9°N. Its main concentrations in Africa are in Sudan along the Nile System, chiefly between the White and Blue Niles (16°-12°N and 32°-33°E) ('great' concentrations at Wedi Medani-Gezira, Walkinshaw 1973) and along Bahr-el-Arab (500-600 *c* 10°N, 25°E, P. Hogg pers. comm.). The Common Crane also winters in Ethiopia chiefly at Koka Reservoir (8°N, 39°E) where about 1000 regularly occur every December and January. Its total population in Africa is unknown but its large numbers suggest it is not endangered there.

The Demoiselle Crane is resident in North Africa in Morocco and possibly also Algeria and Tunisia, and a winter visitor in northeast Africa south to central Sudan and Ethiopia, then west to northeast Nigeria; no Demoiselle Cranes are known to cross the western Sahara. The main wintering concentrations are found between 16°-9°N from northeast Nigeria in the west to central western Ethiopia in the east. Nine hundred have been reported at Kikwa in Nigeria (Elgood 1982), and several thousand winter in Sudan mainly south of Khartoum and north of the Sobat River. The status of this species in Ethiopia is unknown, although it probably is common in some localities. The large wintering numbers indicate that the Demoiselle Cranes from Eurasia are not endangered, although the resident population in Northwest Africa is, with seven individuals in Morocco (Fez, Middle Atlas) being the only birds known to have bred in Africa in the last few years (Latta and Archibald, 1980; Archibald et al. 1981). Elsewhere in North Africa, in the 1940's it bred in Tunisia, but in Algeria not since the early 20th century. Its present population is unknown, but must number less than a few hundred at most.

The total population of the Black Crowned Crane is not known, but up to the early 1970s it probably numbered low tens of thousands. It was widespread and locally common in northern and central Nigeria, and locally abundant in the northern Cameroon's Wazi National Park, where 7000 to 12,000 congregated in February-March (Fry 1981, this volume), and the Sudan, where several thousands were reported in Makalal (Walkinshaw 1973). In West Africa the Black Crowned Crane now exists in two main concentrations: in Senegambia, and between northeastern most Nigeria and central Chad; the intervening regions are evidently now sparsely populated. In the last decade, the species has been reduced in numbers in West Africa, probably due to extensive wetland modification. For example, there are 2500-3500 in Senegambia and Mauritania and hundreds to low thousands in the area covered by Mali, Upper Volta, Ivory Coast, Ghana, and Niger, and in Nigeria there now remain only hundreds in the northeast. It is extinct in Sierra Leone and probably most of northern and central Nigeria. The Black Crowned Crane appears to be facing a very uncertain future in West Africa and should be considered a threatened and endangered species in parts of its range there. Its status in the eastern part of its range from Chad eastward is unknown.

The total number of Wattled Cranes in Ethiopia is unknown, although they are seen frequently at certain times of the year. The total population in central and southern Africa may reach 4000-6000, but its numbers are declining rapidly in some areas. Main concentrations are in Zambia where as many as 300 breeding pairs and 3000 individuals occur in peak seasons on Kafue Flats, 500 at Liuwa, several hundred at Bangweulu and Busanga, and in botswana where 1000 have been seen at Okavango and 2000 nonbreeding birds at Magadigadi (Konrad 1981). It is locally common in Zimbabwe, forming flocks of 40-70 in July-September, frequent in Angola and Zaire, uncommon in Namibia, and rare in Malawi where it may be endangered. Its status in Mozambique and Tanzania is unknown, but probably only small numbers are thought to be there. It is extinct in Swaziland and South Africa's Cape Province, while elsewhere in South Africa it is endangered with only 25-30 pairs known from Transvaal, 40 pairs from Natal and two pairs from Orange Free State (Tarboton 1984). Despite large numbers in some parts of its range, this crane is threatened and even endangered in southern Africa due to the steady loss of habitats caused by increasing human development. This crane may face a very uncertain future there since its main concentrations in Zambia and Botswana are found in areas whose habitats are undergoing great change due to hydroelectric schemes and wetland reclamation (Konrad 1981).

HABITS

General Habits

There are several similarities and differences in the general habits of cranes of Africa; some are discussed below.

Unison call. The unison calls of Black and Grey Crowned Cranes are of indeterminate length, asynchronous, and initiated by either sex. The unison call of the other African species are of determinate length, lasting usually 5-7 sec., synchronous and initiated by the female. The Common Crane's unison call is scream like; Wattled Crane's is high-pitched; Demoiselle and Blue Cranes' are continuous series of raspy calls; Black Crowned Cranes's is a series of honking calls that occasionally ends with a high-pitched booming; and the Grey Crowned Crane's is a brief series of 'o-wan' calls followed by a prolonged booming. Male and female crowned cranes may or may not stand side-by-side when calling, while male and female of the other species stand side-by-side. Female Common Cranes give three short calls for each male call; in the other species one female call is given for every male call. When giving the unison call, both male and female Grey Crowned Cranes first hold the neck upright, then lower the head to the shoulder as each booms; neither moves its wings at this time. Male and female Black Crowned Cranes also hold the neck upright but they do not lower the head to the shoulder when giving the unison call. In other species males and females move their bodies differently when giving the unison call. Both sexes of the Common Crane first hold the head slightly forward with the bill pointing up, then bend the neck slightly backwards and lift the wings up. At this time the male, but not the female, droops the primaries toward the ground. Both sexes of Wattled Cranes coil the neck, then shoot it up as they call; neither moves its wings although the male has its wings raised about 20° above its back. Both male and female Demoiselle Cranes hold their wings close to their body; the female extends the neck 45° back of the vertical while the male extends his neck straight up and angles his bill 45° above the horizontal. The female Blue Crane holds her neck 20° back of the vertical and keeps her wings closed; the male Blue Crane extends his neck vertically, slightly opens his wings and raises them high above his back but droops his primaries to his legs.

Habitat. All cranes in Africa inhabit open grasslands, marshes, and edges of rivers and lakes. The Demoiselle Crane, however, tends to inhabit more semiarid areas than the others, while the Wattled Crane prefers highland marshes, wet meadows, and grasslands, and the Blue Crane tends to be more in grasslands and less in marshes.

Roosting behavior. All roost on the ground, sometimes in water, and often in large numbers. Crowned cranes also roost in trees.

Foraging behavior. Cranes in Africa dig and peck for food in open areas. The Wattled Crane has the most specialized foraging behavior, digging sedge tubers and rhizomes in highland wetlands, meadows, and wet grasslands; it almost never forages on drier agricultural fields, but occasionally takes grain, insects, and other small animals. The Common Crane digs and pecks, taking plants and animals including roots, shoots, grain, various terrestrial invertebrates, and small vertebrates. Demoiselle and Blue Cranes largely peck for grain but also take other plants and small animals. Crowned cranes largely peck for food, taking grain, other plants, and small animals. They also occasionally dig for food, and, unlike other African cranes, stamp their feet when foraging, presumably to flush the small animals on which they prey.

Molt. Demoiselle and crowned cranes do not undergo complete molt. Common and Blue Cranes undergo complete molt once every two years, becoming flightless for up to six weeks. The Wattled Crane also undergoes complete molt and becomes flightless, but it is not known if it does so once every year or every other year.

Migration. The Common Crane, whose migratory routes are fairly well known, reaches Morocco, Algeria, Tunisia, and probably western Libya via Gibralter and southern Italy and Sicily, and eastern Libya and Egypt via Cyprus. The majority follow the eastern Mediterranian shoreline to Egypt, Sudan and Ethiopia with some also crossing Saudi Arabia and the Red Sea. In contrast, the migratory routes of the Demoiselle Crane are poorly known. It is known to migrate along the Nile and is suspected of crossing the Red Sea.

Details of movements and possible migrations of resident African cranes are also poorly recorded. It is unknown if resident Demoiselle Cranes of northwest Africa migrate. All other African cranes are known to move locally to marshes in the rains and away from them in the dry season; specific distances moved, however, are unknown. Although the exact movements of Wattled Cranes in southern Africa remains a mystery, this species may move extensively since the departure of large numbers from Zambia corresponds with an increase in Botswana. The Blue Crane is suspected of migrating between South Africa and Namibia.

Breeding Habits

Some similarities and differences in the breeding habits of African cranes are discussed below.

Courtship. Although the courtship behavior of African cranes is poorly documented, it seems to be very similar in all species. All dance in circles, bow, and jump with wings spread and neck stretched out.

Nests. The Demoiselle Crane lays its eggs in a relatively bare shallow cup. The Blue Crane also uses a shallow cup but it places some reeds and pebbles in it. The Wattled and crowned cranes build circular platforms of sedges and grasses surrounded with water in marshes.

Eggs. All lay 1-2 eggs, rarely 3 or 4.

Laying Dates. African cranes nest mainly in some part of a rainy season. In southern Africa, the Wattled Crane nests when flood waters recede, while in Ethiopia it nests just before or during the rains. The Blue and crowned cranes nest mainly in the rainy season, as does the Demoiselle Crane, which breeds in Morocco in the Palearctic spring.

Incubation. Periods of incubation of African cranes are very similar, ranging from 27-29 days in Demoiselle Crane to 28-31 in Black Crowned Crane, 29-31 in Grey Crowned, 30 in Blue Crane, and 32-33 in the Wattled Crane.

Fledging/postfledging periods. Little is known about fledging and postfledging periods of African cranes. All fly at about 3-4 months of age and remain with their parents until 7-12 months of age.

Breeding success. Breeding success of cranes of Africa is poorly known. The data available indicate that the Grey Crowned and Blue Cranes are successful, with about one young/pair reported in the former (Pomeroy 1980a), and 25 of 28 eggs hatched in the latter (Walkinshaw 1963). The Wattled Crane has the lowest reproductive rate of any crane (Konrad 1981), its breeding success varying from one young/pair in Zambia (Benson and Pitman 1964) to 0.61 young/pair in Transvaal (Day 1980) to 0.13 young/pair in Zambia (Konrad 1981). Disturbances by man (who eats eggs and young), *Varanus* lizards, flooding, and development projects contribute to the low breeding success in the Wattled Crane. No data are available for breeding success in Demoiselle and Black Crowned Cranes.

RECENT STUDIES

Even though they are large in size and sometimes occur in large concentrations, cranes in Africa have not been studied extensively. For example, the general features of the Common Crane's range, status, migratory routes, and dates of arrival and departure in Africa are known (see for example Cheesman & Sclater 1935, Cramp & Simmons 1980, Guichard 1956, Mathiasson 1963, Meinertzhagen 1949, Moreau 1967, Smith 1965, van der Ven 1981). Yet, no one has studied this species on its wintering grounds in detail. Not even the exact locations and numbers of the major concentations, such as those in Sudan or Ethiopia, are known.

Even less is known about the Demoiselle Crane in Africa. Like the Common Crane, its range, status and migratory routes are generally known (see for example Cheesman & Sclater 1935, Elgood 1982, Mathiasson 1963, Moreau 1967, Newby 1979, Salvan 1967-68, Smith 1965) but the exact locations and numbers of its major concentrations have not been reported in the literature. Even the autumn arrival and spring departure, known in the Common Crane, are virtually unrecorded in the Demoiselle Crane, as is its migratory route across the Red Sea. Although it is known to occur in certain areas such as central western Ethiopia and is thought to be locally common, its abundance there is unknown. The small endangered resident population in northwest Africa is scarcely known at all.

The Wattled Crane has been studied in some detail in southern Africa, especially because of its endangered status there. Some recent studies of the species are those by Konrad (1981) on status and ecology, Douthwaite (1974) on the endangered population in Kafue Flats in Zambia, West (1976) on distribution and status, Tarboton (1984) on status and conservation in Transvaal, and the Crane Working Group (Day 1980). In contrast, the biology of this crane in Ethiopia has hardly been studied, and only its distribution has been analyzed within the last 15 years (Urban & Walkinshaw 1967). Additional studies are needed on distribution, population status, wetland use, social structure, migrations and movements, and nesting success and productivity. Conservation programs must also be developed to assist local authorities in regulating the Wattled Crane's habitat in areas that have been or will be changed due to hydroelectric schemes and wetland reclamation. Programs are also needed to reestablish this species in areas from which it has disappeared.

The breeding behavior and life history of the Blue Crane have been reported by Walkinshaw (1963) and Van Ee (1966). Van Ee (1981) recently surveyed the status of this species and found its population healthy and nowhere endangered. Even though this species' general and breeding habits are known, detailed studies of its social structure, migrations, nesting success, and productivity are needed.

Recently the systematics of the crowned cranes has been analyzed biochemically by Ingold et al. (this volume). In addition, parts of the breeding biology of the Black Crowned Crane have been reported on by Walkinshaw (1964, 1966). Urban and Walkinshaw (1967) analyzed its distribution in Ethiopia, and Owre (1966) discussed its occurrence in the Lake Turkana region. Fry (1981, this volume) described its status in West Africa, and Urban (1981) did so for eastern Africa. The Grey Crowned Crane's growth, ecology, and status have recently been analyzed in Uganda by Pomeroy (1980a and b); Frame (1982) discusses its ecology and behavior in Tanzania (Serengeti and Ngorongoro Crater); Burke (1965) reported on its density in parts of Kenya; and Walkinshaw (1964) studied its life history in southern Africa. Numerous comments on its biology have also appeared in notes and regional accounts (see bibliographies in Walkinshaw 1973 and Urban, Fry and Keith 1986). Detailed studies are still needed on population density, social structure, nesting success and productivity of these species, especially the Black Crowned Crane because of its possible threatened and even endangered status in parts of its range.

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BIOCHEMICAL SYSTEMATICS OF THE CROWNED CRANES

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ABSTRACT

We performed an electrophoretic analysis of representatives of eight nominal taxa of cranes to elucidate systematic relationships between the two crowned cranes (*Balearica*). Twenty-one presumptive genetic loci were consistently resolved. The two crowned cranes have a Nei's unbiased genetic distance (D) of 0.115. Within *Grus*, all D values are less than or equal to the value for the crowned cranes. The present data strongly suggests that there are two species of crowned cranes.

INTRODUCTION

The avian family *Gruidae* is composed of two subfamilies, the *Gruinae*, which contains thirteen species in three genera, and the *Balearicinae*, the crowned cranes. There is some controversy as to whether there are one or two species of crowned cranes. Snow (1978) and White (1965) erect one species composed of four distinct subspecies while others (Archibald 1976, Walkinshaw 1964, 1973, E.K. Urban, pers. comm.) believe that there are two species, the Black Crowned Crane (*Balearica pavonina*) and the Grey Crowned Crane (*Balearica regulorum*), each having two distinct subspecies. The West African Crowned Crane (*B.p. pavonina*) and the Sudan Crowned Crane (*B.p. ceciliae*) are the recognized subspecies of the Black Crowned Crane while the South African Crowned Crane (*B.p. regulorum*) and the East African Crowned Crane (*B.p. gibbericeps*) are considered the subspecies of the Grey Crowned Crane. Characters used to separate the various subspecies can be found in Walkinshaw (1964). Archibald (1976) found that the two subspecies of the Grey Crowned Crane have identical unison calls; these differ, however, from those of the Black Crowned Crane.

As the common names of the four subspecies imply, all have different distributions on the African continent (Walkinshaw 1964). Although the crowned cranes are still abundant both in the wild and in captivity, recent evidence suggests that the numbers of the Black Crowned Crane have been drastically reduced. It is therefore important that the question of species relationships be resolved in light of conservation efforts for endangered species. In an attempt to elucidate systematic relationships between the crowned cranes, we performed an electrophoretic analysis of representatives of eight nominal taxa.

METHODS AND MATERIALS

Blood (10 ml) was collected from two individuals of each of eight species of cranes (Black Crowned Crane; Grey Crowned Crane, one individual of each subspecies; Sarus Crane, (*Grus antigone*); Red-crowned Crane, (*G. japonensis*); Hooded Crane, (*G. monacha*); Sandhill Crane, (*G. canadensis*); Brolga, (*G. rubicunda*); White-naped Crane, (*G. vipio*). Samples were collected from the captive breeding flock at the International Crane Foundation (ICF), Baraboo, Wisconsin by J.L. Ingold and ICF personnel.

Upon collection, blood was centrifuged at 3,000 rpm for 10 minutes, the plasma decanted, and frozen at -75°C. The pellet was washed three times in avian saline, mixed with a volume of avian saline 3x the volume of packed cells, frozen, thawed, shaken vigorously and then centrifuged at 3,000rpm for 10 minutes. The red cell hemolysate was decanted and kept frozen at -75°C. The pellet containing the nuclei was frozen at -75°C for use in DNA-DNA hybridization studies to be conducted.

The horizontal starch gel electrophoretic techniques and recipes of Selander et al. (1971) were employed in conjunction with the staining procedures of Brewer (1970). The following 18 presumptive genetic loci were consistently resolved from the red cell hemolysate: lithium hydroxide buffer—glucokinase (GK), leucine aminopeptidase (LAP-1), and superoxide dismutase (SOD-1, -2); tris-citrate buffer (pH 8.0)—catalase (CAT), lactate dehydrogenase (LDH), phosphoglucomutase (PGM-1, -2), and peptidases (D-leucyl-L-tyrosine) (PEP-1, -2); Poulik buffer—esterases (EST-1, -3); Clayton-Tretiak buffer—hemoglobin (HB), malate dehydrogenase (MDH-1, -2), phosphoglucose isomerase (PGI): triscitrate buffer (pH 6.0/6.7)—mannose phosphate isomerase (MPI); tris-HC1 buffer (pH 8.5)—6-phosphogluconate dehydrogenase (6-PGDH). The following three presumptive genetic loci were consistently resolved from plasma with lithium hydroxide buffer: albumin (ALB), leucine aminopeptidase (LAP-2), and non-specific protein (TP). A matrix of Nei's (1972) genetic distance and Nei's (1978) unbiased genetic identity values was generated from the electrophoretic data. Cluster analysis of this matrix was performed with the unweighted pair-group method with arithmetic averaging (UPGMA) using the BIOSYS-1 program (Swofford & Selander, 1981).

RESULTS AND DISCUSSION

Intraspecific genetic variation occurred at only 2 of 21 (10 percent) loci sampled (PGM-1 and PGM-2), all variants were heterozygotes. Within the family 9 of 21 (43 percent) loci sampled were polymorphic (*Table 1*).

The two subspecies of the Grey Crowned Crane shared identical alleles at all loci sampled. A matrix of Nei's (1972) genetic distance and unbiased genetic identity (1978) is presented in *Table 2*. The two crowned cranes have a genetic distance and genetic identity of 0.115 and 0.895 respectively. Within *Grus* all distance and identity values are indicative of greater similarity than those for the crowned cranes with the exception of those values comparing the Hooded and Sarus Cranes. $\bar{D}$ and $\bar{I}$ for the species used in this study were 0.113 (0.000-0.312) and 0.872 (0.738-1.000) respectively. Values for all *Grus* spp. are $\bar{D}$ = 0.065 (0.000-0.115) and $\bar{I}$ = 0.939 (0.895-1.000) (Ingold et al., this volume). These values compare favorably for other avian species groups (Avise & Aquadro 1982). A phenogram based on the genetic identities (*Fig. 1*) has a cophenetic correlation coefficient of 0.97. The two species of *Balearica* cluster together and apart from the six species of *Grus*.

The electrophoretic data strongly suggest that there are indeed two species of crowned cranes. Genetic identity between the crowned cranes is lower than the identities obtained when comparing different species of *Grus*, all which are no doubt good species. One can be confident then that the crowned cranes have been separated long enough to provide a large amount of genetic divergence at the molecular level. Although sibling species in birds are not common, they do occur (Mayr & Short 1970). When one is concerned with identifying

Table 1. Allelic Frequencies observed in Gruidae. *a*

Protein locus	*Balearica pavonina*	*Balearica regulorum*	*Grus antigone*	*Grus japonensis*	*Grus monacha*	*Grus canadensis*	*Grus rubicunda*	*Grus vipio*
GK								
A		100						
B	100			100				
C			100					
D					100	100	100	100
MPI								
A								
B	100	100	100	100	100	100	100	100
PEP-1								
A	100							
B		100	100	100	100	100	100	100
PEP-2								
A			100			100	100	100
B	100	100						
C				100	100			
6-PGD								
A	100	100	100	100	100	100	100	100
PGM-1								
A	50							
B	50	100	100	100	100	100	100	100
PGM-2								
A	100	100	100	100	50	100	100	100
B					50			
SOD-1								
A			100	100	100	100	100	100
B	100	100						
SOD-2								
A			100	100	100	100	100	100
B	100	100						

a All species were monomorphic for the same electromorph at CAT, EST-1, EST-3, HB, LDH, LAP-1, LAP-2, MDH-1, MDH-2, PGI, ALB, and TP.

species, there is a need to look at more than gross external morphology. The crowned cranes have been studied with a variety of systematic techniques and all evidence points towards two distinct species. However, neither biochemical or behavioral data show differences between the two subspecies of the Grey Crowned Crane.

Now that we have determined that there are two species of crane, what effect does this knowledge have on conservation efforts? The most immediate effect is the reduction in numbers of individuals of each species, due to the split. This reduction in numbers is important in light of the drastic decline in numbers reported for the Black Crowned Cranes by C.H. Fry (this volume). Probably of greater import is the problem associated with

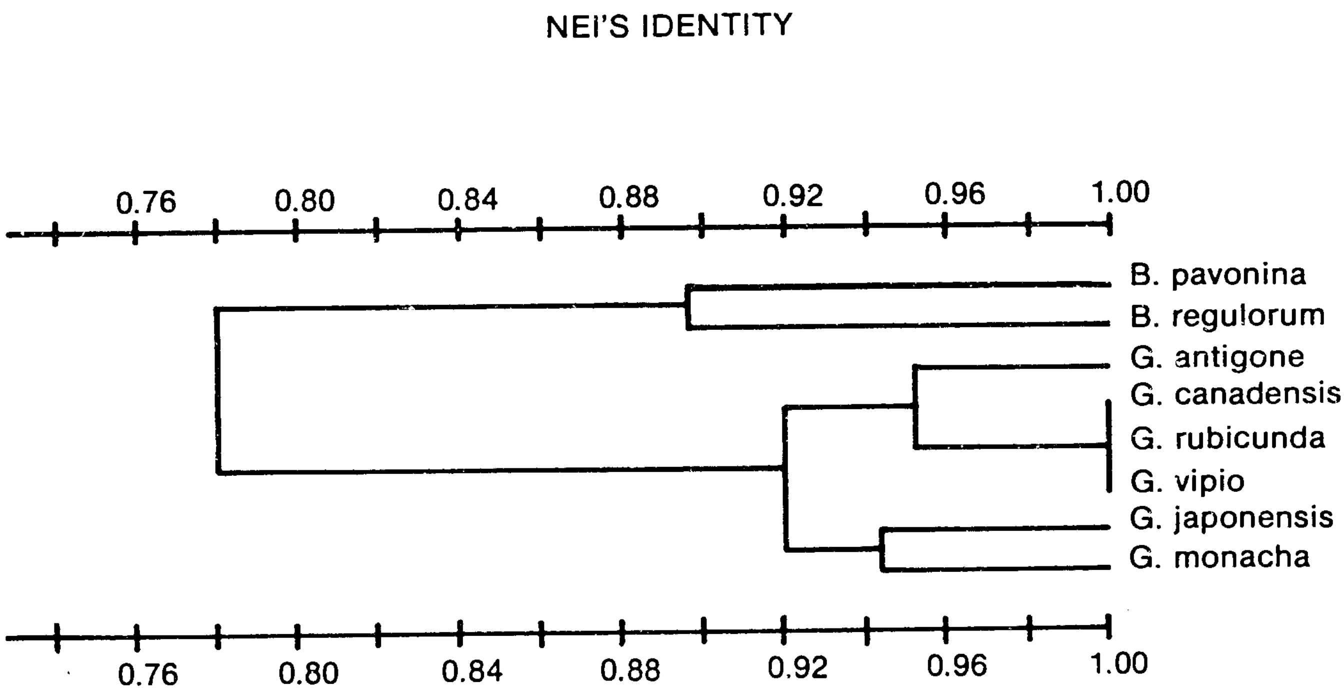

Fig. 1. Phenogram for crane species using Nei's (1978) unbiased genetic identity.

Table 2. Genetic distance (above diagonal; Nei 1972) and unbiased genetic identities (below diagonal; Nei 1978) between species of cranes, based on electrophoretic analysis at 21 loci.

SPECIES	1	2	3	4	5	6	7	8
1. *Balearica pavonina*	*****	0.115	0.292	0.229	0.312	0.292	0.292	0.292
2. *Balearica regulorum*	0.895	*****	0.211	0.211	0.229	0.211	0.211	0.211
3. *Grus antigone*	0.750	0.810	*****	0.100	0.115	0.049	0.049	0.049
4. *Grus japonensis*	0.798	0.810	0.905	*****	0.062	0.100	0.100	0.100
5. *Grus monacha*	0.738	0.798	0.895	0.944	*****	0.062	0.062	0.062
6. *Grus canadensis*	0.750	0.810	0.952	0.905	0.944	*****	0.000	0.000
7. *Grus rubicunda*	0.750	0.810	0.952	0.905	0.944	1.000	*****	0.000
8. *Grus vipio*	0.750	0.810	0.952	0.905	0.944	1.000	1.000	*****

reintroduction of birds into the wild. If it comes to the point where wild populations of crowned cranes are so low that it is necessary to reintroduce captive raised birds, it would be important to know which species should be placed in a particular area. With the realization that there are two species of crowned cranes, we can avoid the controversy surrounding the reintroduction of nonnative subspecies into an area, a problem that has plagued the Peregrine Falcon (*Falco peregrinus*) recovery program (A.O.U. 1977).

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THE ECOLOGY AND STATUS OF CROWNED CRANES IN EAST AFRICA

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ABSTRACT

The Crowned Crane (*Balearica pavonina*) is widespread in East Africa, only being absent from the driest regions in the northeast and southeast, and montane regions above about 300m, and the coastal plains.

Typically, this crane is a bird of short and medium grasslands in areas with an annual rainfall exceeding 750mm. It requires swamps for breeding but at other times can be found far from water. There is evidence that the annual mortality rate for adults is about 12%, so that some individuals are likely to live for 15-20 years. This is associated with relatively low breeding success, and strong circumstantial evidence that only a proportion of the adult population breeds in any one year — in some cases less than half.

The Crowned Crane in East Africa has adapted well to environmental changes. In recent years, the largest recorded flocks, in both Kenya and Uganda, are on farms, ranches and playing fields — in all cases these occurred in the late dry/early wet season, and typical maxima were around 200.

In some areas cranes are unpopular with farmers, damaging newly-sown crops or pecking seeds from ripening cereals. They also consume grasshoppers and in that way are beneficial.

Jackson, writing of the period from 1884 to 1917, described the distribution and abundance of this species in terms which apply well today, and thus it seems that there has been little change during the present century. At times birds have been exported, mainly to zoos, but there is no evidence that this caused any appreciable decline in their population.

Since cranes occur commonly on most types of agricultural land from small holder farms to large modern ranches, there is no immediate likelihood that modernization of farming methods will affect them adversely. The greatest risk is that draining of swamps, as yet an uncommon practice in most areas, will accelerate, with the consequent loss of breeding sites. The effects of increasing pesticide use are also hard to predict.

At present, the population of *Balearica pavonina* in East Africa is probably of the order of 100,000 birds.

INTRODUCTION

Crowned Cranes occur widely in East Africa. Those in northern Uganda and Kenya are sometimes placed in a different species (e.g. Urban et al. 1986 and Mackworth-Praed & Grant 1957); but I prefer to follow Britton (1980) and Snow (1978), who considered all Crowned Cranes as a single species, with the dark-necked northern form as a distinct race, *Balearica pavonina ceciliae*. There are, however, few East African data on this form, and all records in this paper refer to *B.p. gibbericeps* unless otherwise stated.

Crowned Cranes have been studied in all three East African countries: by Burke (1965), Sessions (1966) and van Someren (1958) in Kenya, Pomeroy (1980a, b) in Uganda, and by Frame (1982) in Tanzania: however, none of these was a detailed investigation. This paper draws freely on the writings of those workers, and adds new material for Kenya, based on my observations between 1975 and 1982.

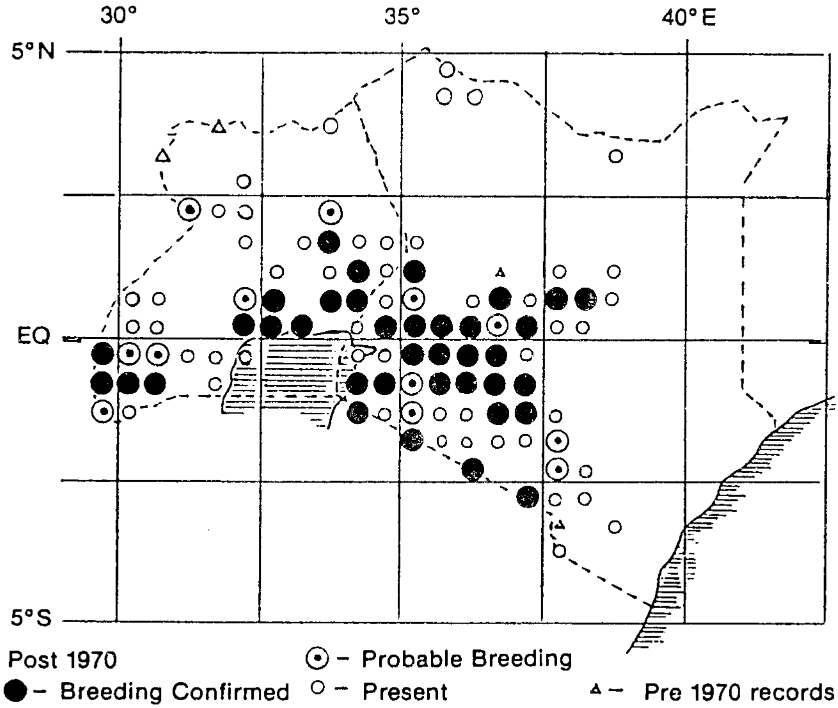

Fig. 1. The distribution of Crowned Cranes in Uganda and Kenya as recorded by atlas schemes based on squares of ½° latitude by ½° longitude. Data are still being accumulated; the Figure shows information to December 1983. It is likely that Crowned Cranes actually occur throughout southern Uganda, at least to 2°N. Records for Kenya from A.D. Lewis & D.E. Pomeroy (in prep.) and G.R. Cunmingham-van Someren (pers. comm.); for Uganda unpubl. records of J.S. Ash, J. Baranga, M. Carswell and D.E. Pomeroy.

DISTRIBUTION

There are fairly detailed records for the distribution of Crowned Cranes in Uganda and Kenya (*Fig. 1*). The scattered records in the north of both countries probably all refer to *B.p. ceciliae*, but this is not certain. Within Kenya, where records approach complete coverage, the distribution is relatively compact, with breeding or probable breeding occurring in 32 of the 58 squares (55%) in which the southern population has been recorded since 1970. Since breeding cranes are fairly conspicuous, this pattern of records suggests that they do not wander extensively; the records from the coast are unusual. The data for Uganda, though rather less complete so far, probably reflect a similar situation. It is noticeable in both countries that many of the squares with nonbreeding records are peripheral, perhaps because subadults disperse to these areas.

The Kenya records shown in *Fig. 1* have been analyzed in relation to rainfall and altitude. This was done by noting for each ½° by ½° square, for which adequate records exist, the mean annual rainfall and altitude (Pomeroy, Lewis & Mutere 1982). Then the percentage of squares where Crowned Cranes had been recorded was determined for each of four

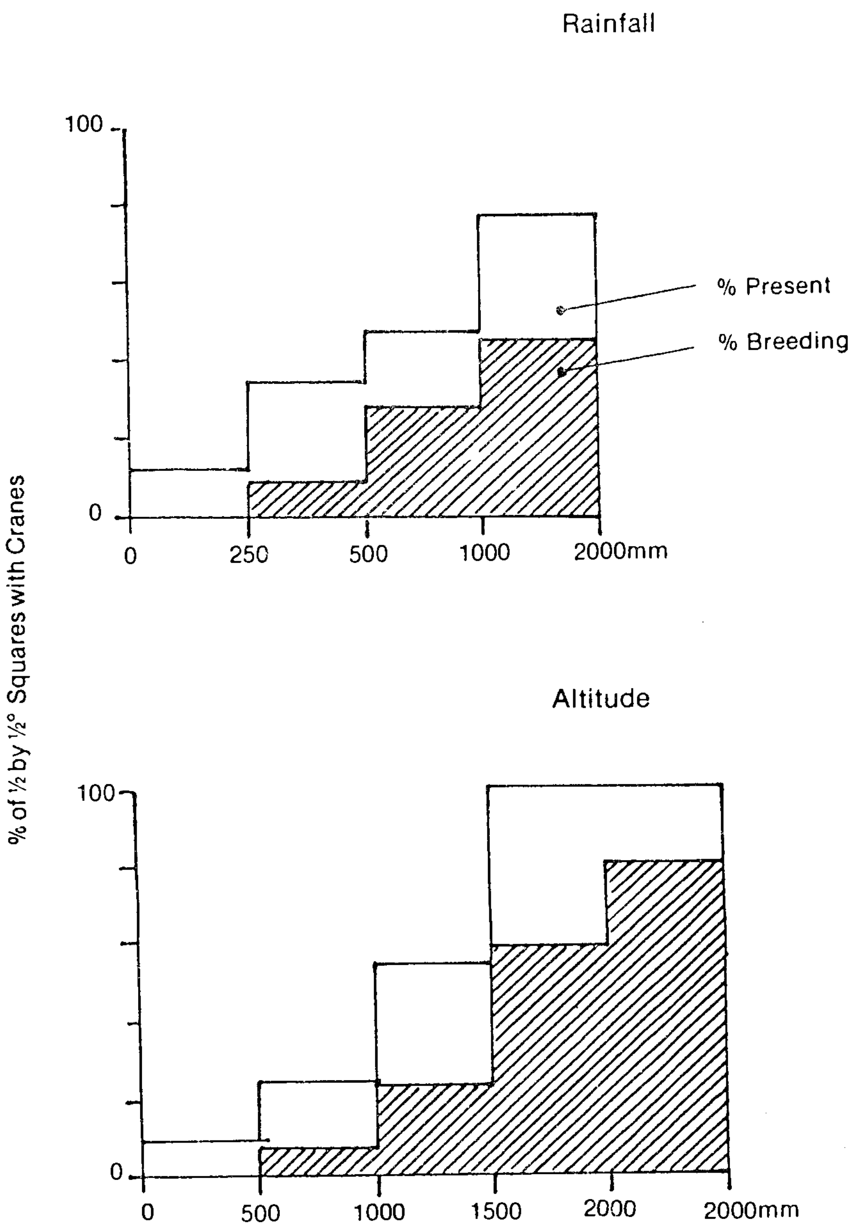

Fig. 2. The frequency of Crowned Crane records in each of several categories of rainfall and altitude, using the ½x½° squares plotted in *Fig. 1.* Thus the birds were present in 77% of the squares having 1000-2000mm of rain per year, and were recorded as breeding (or probably breeding) in 45% of those squares. Data from Lewis & Pomeroy (in prep.).

categories of rainfall and five categories of altitude (*Fig. 2*). It is clear that Crowned Cranes occur mainly in the montane areas (above 1500m), especially where the rainfall exceeds 500mm annually. Indeed, they breed at altitudes up to about 3000m (Sessions 1966).

Of the two factors shown in *Fig. 2*, altitude is the more important, since there are no records for coastal Kenya, where several squares have rainfall exceeding 1000mm annually. Altitude closely reflects temperature; in East Africa an altitude of 1500m is equivalent to a mean annual temperature of 20°C.

Britton (1980) records that the species occurs throughout Tanzania excepting the coastal lowlands and southeast, although it has not been recorded breeding east of Arusha National Park.

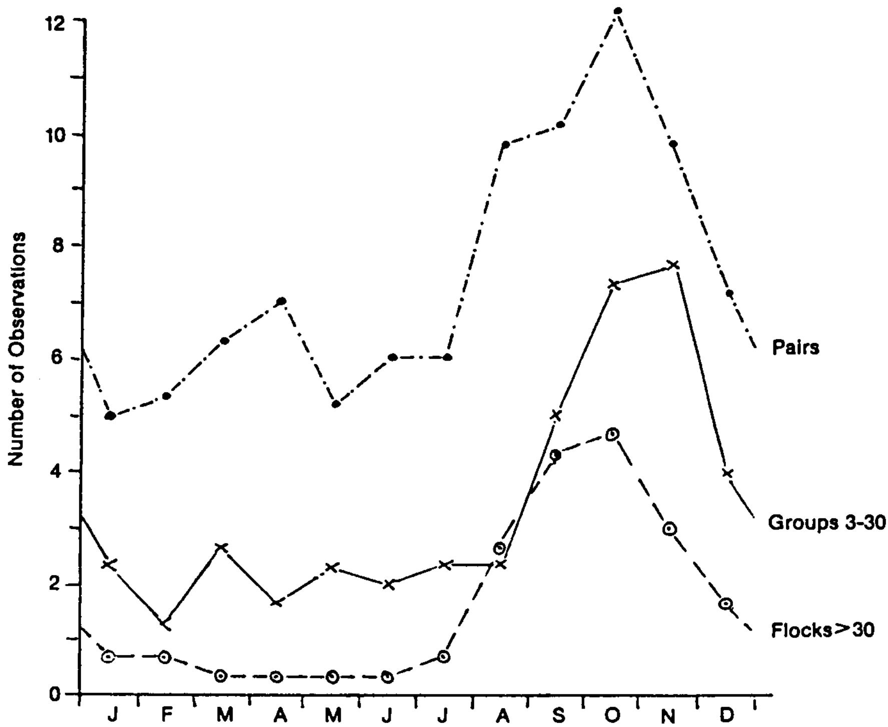

Fig. 3. The frequency of observations in Kenya of pairs, groups of 3-30, and flocks of more than 30. The records cover most of southern Kenya but were not collected systematically. Rather, all observations were noted as opportunity offered. The data have been arranged in 3-point running means, e.g. the points for January are the averages of the raw data for December, January and February.

SEASONALITY AND BREEDING

Crowned Cranes are most commonly seen in pairs (*Fig. 3*; see also Frame 1982 and Pomeroy 1980a). Flocks, sometimes exceeding 100 birds, are also frequent in some areas. In Kenya, pairs, groups of 3-30, and larger flocks, were all seen most frequently between August and December, which is the nonbreeding season (*Fig. 4*). However, there is an interesting difference in the timing of breeding in Kenya and Uganda. In Uganda, breeding occurs throughout the year, and although there are two peaks they are much less marked than the single peak in Kenya (*Fig. 4*). In their treatment of breeding seasons,

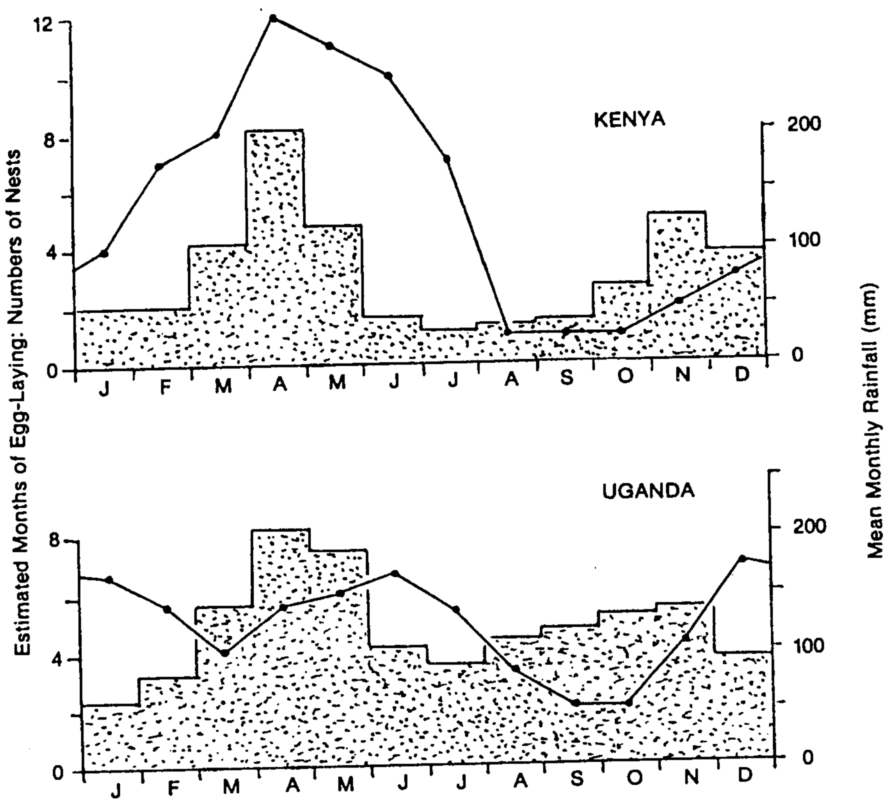

Fig. 4. Seasonality of nesting records (graphs) compared to rainfall (strippled) for Kenya and Uganda. The rainfall data are generalized for regions D and B respectively of Brown & Britton (1980). Nesting is recorded against the month in which egg-laying occurred, or was estimated to have done so on the basis of the plumage of immatures (see Pomeroy 1980b). Uganda data redrawn from Pomeroy (1980a), Kenya data from Brown & Britton (1980), personal observation, and the Newsletter of the Department of Ornithology, National Museums of Kenya.

Brown & Britton (1980) place most of Tanzania in 'region C,' where Crowned Cranes also show a single peak of breeding, between December and May, which is the rainy season there. Additional records of Frame (1982) are consistent with this.

Just as the breeding seasons in Uganda were not clearly defined, so the numbers of pairs seen in each month varied much less than in Kenya, but were most frequent at the time of the December-January breeding peak (Pomeroy 1980a).

The geographical differences between the breeding seasons of the various Crane populations can be related to rainfall. Uganda has the highest rainfall of the three regions considered (corresponding approximately to regions B, C and D of Brown & Britton (1980)), and there the birds nest throughout the year. However, there are less nests in the wet seasons (*Fig. 4*), perhaps because of the risk of their being flooded. In the Kenyan and Tanzanian regions, rainfall is less and seasonal variations are likely to be greater than in Uganda. The breeding season in Kenya and Tanzania corresponds to the 'long rains,' and is almost certainly the time of maximum food abundance.

POPULATION BIOLOGY

Like most tropical birds, Crowned Cranes probably have a low mortality rate once they survive the first year or so. Brown & Pomeroy (in press) showed that adult mortality rates are related to size, as measured by mass. Adult Crowned Cranes have an average mass of 3.5kg (Pomeroy 1980b) and the predicted annual adult mortality rate corresponding to this is 4.9%.

Brown & Pomeroy (1984) used a second method of estimating population mortality rates (which include immatures as well as adults). Their method is based upon the proportion of immatures in the population, and predicts a rate of 11.7% annually. Mortality in the first year of life (starting with the egg) is of the order of 45% in Kenya and Uganda (*Fig. 5*); a small sample from northern Tanzania indicated a somewhat higher rate (Frame 1982). In the second year of life, a rate of 10-20% per year might be expected, falling to the adult rate of about 4.9% per year by the age of three or four. A population with an age structure of that sort would involve some individuals living to an age of 20 to 25 years.

Pairs of Crowned Cranes are often accompanied by their young, but very few immature birds are found in larger groups or in flocks. Apparently it is general for the immatures to stay with their parents until they are nearly a year old, as Sessions (1966) observed. At this age, their plumage becomes indistinguishable from that of their parents (Pomeroy 1980b). Sessions noted that the young left their parents at about this time, and joined a nearby flock.

The proportion of the population that breeds in southern Kenya can be estimated as follows. During the breeding season, taken as January to July, the monthly average number of birds recorded in pairs was 13.2. (Single birds are also counted as pairs, since they usually indicate a partner at the nest). The average number of birds in groups (3-30

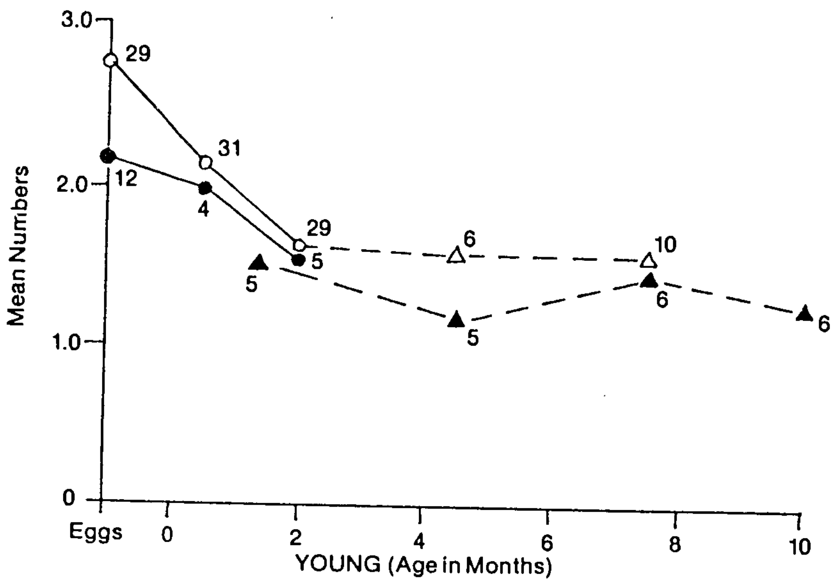

Fig. 5. Breeding success of Crowned Cranes in Uganda and Kenya. The figures alongside each point are the number of observations. Redrawn from Pomeroy (1980a), with additional data from Kenya.

highland / medium altitudes: ○—○ / ●—● Data from EANHS record Scheme; △— —△ Author's observations; ▲— —▲ Author's observations birds) was 8.3, and 7.1 observations of flocks (more than 30 birds) (*Fig. 3*). Thus 13.2 observations out of 28.6 (or 46%) were of pairs. This is probably an underestimate, since groups were obviously more conspicuous, but it suggests that about half of the population actually breeds each year. Once a pair starts to breed, they do so every year, or more frequently if they are unsuccessful (Sessions 1966). It follows that the nonbreeding half of the population are mostly subadults; this would be consistent with an age of first breeding in the region of four to six years (cf. Brown & Pomeroy, in press), as in other species of cranes (Walkinshaw 1973).

The sharp increase in records of Crowned Cranes observed in Kenya between August and December (*Fig. 3*) is in marked contrast to southern Uganda, where flocks were present throughout the year, and in the Serengeti region of northern Tanzania where they also occurred in most months (Frame 1982). Nevertheless, Frame found that there were fewer flocks on the Serengeti Plains in September-October, when the area was very dry. This corresponds to the time when flocks were arriving in southern Kenya; most of those contributing to *Fig. 3* were within 100 to 300km of the Serengeti. It was suggested earlier that movements of Crowned Cranes in East Africa were unlikely to be extensive, but distances of this order are not great.

Interestingly, although most observations in Kenya were in the central part of the country, flocks of Crowned Cranes on the slopes of Mt Elgon, near to the border with Uganda, arrive in August, the same time as farther east. Up to 100 are seen in wheatfields around Elgon until December, when they disappear (B. Tengecho, pers. comm.).

DISCUSSION AND CONSERVATION STATUS

Crowned Cranes occur over about half of East Africa, whose total area is some 1,760,000km². In favourable areas the population density can be quite high. Burke (1965) found a density of 34 birds per 100km² in an area of western Kenya, while Sessions (1966) had two resident pairs in about 8km². If we take a much lower figure for the *average* density within their range, of only 2 pairs per 100km², and further assume that the breeding birds are only half of the population, then we would have an estimate of about 70,000 birds for the whole of East Africa. This is clearly a very approximate figure, but should be considered as a minumum estimate. Certainly Crowned Cranes are not threatened with imminent extinction.

Writing of the early years of this century, Jackson (1938) described the distribution and abundance of Crowned Cranes in Kenya and Uganda in terms which apply well today, suggesting that there has been no great change during that period. But there are several ways in which the situation could change. Typical breeding sites are seasonal swamps, and the combination of increasing human populations and improved agricultural techniques is leading people to drain swamps, often to grow rice. Fortunately many of East Africa's National Parks contain suitable breeding sites.

The bird trade is another threat since Crowned Cranes are not only very attractive, they also make congenial pets. In 1979, 445 Crowned Cranes were exported from Kenya (G.R. Cunmingham-van Someren, pers. comm.), the leading markets being Holland (147), the USA (130) and Japan (130). For such reasons the species is described in the Red Data Book as "Vulnerable."

On the other hand, some human activities are favourable to Crowned Cranes, and could allow their populations to increase in certain areas. They are essentially birds of open grasslands, especially where the grass is of short or medium height, and some of the largest flocks are seen on farmland. The extensive clearance of highland forests and woodlands, which began early in the present century, may well have increased the area of habitat suitable for them. When questioned, farmers (including peasant farmers) often complain of the damage to their crops by Crowned Cranes, especially the uprooting of seedlings, but they seem to do little to prevent it, beyond sometimes chasing the birds away.

Crowned Cranes are adaptable. Their diet is catholic (Pomeroy 1980a), and they have taken to man-made grasslands, including fields of wheat and maize. The contrast in seasonal activity between Uganda, where breeding occurs throughout the year, though peaking early in the dry season, and the drier areas of Africa such as Kenya where they breed in the rains, shows their ability to survive in a range of ecological conditions. However, it remains true that our knowledge of this bird's biology is inadequate; for more confident predictions we need to know much more about their population size and habitat requirements.

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NEW DATA ON THE STATUS OF THE BLACK CROWNED CRANE IN WEST AFRICA

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ABSTRACT

Recent information on the status in West Africa of the Black Crowned Crane is summarized in *Fig. 2* (compare with *Fig. 1* in Fry 1981). There are 2500-3500 birds in westernmost Africa, up to 10,000 in the Lake Chad basin, and at most a very few thousands in the whole of the intervening region. In Nigeria, the species is evidently now extinct in three or four areas where it was common 10-20 years ago and elsewhere is highly localized and probably at real risk of national extinction.

INTRODUCTION

A survey conducted in 1974 on the status in West Africa of the Crowned Crane (*Balearica pavonina*) (now called the Black Crowned Crane in distinction from its allospecies *B. regulorum*, the Grey Crowned Crane of eastern and southern Africa) indicated that there were then two main distributional foci. Concentrations existed in Senegambia and between central Nigeria and central Chad; in intervening regions the species was distributed rather sparsely (Fry 1981).

During visits in 1979 and 1981 to some parts of Nigeria where cranes were formerly common I encountered none at all. Data provided early in 1983 by ornithologists presently or recently resident in Nigeria and other West African countries, strongly suggest that there has been a dramatic contraction of range and concomitant decline in abundance of Black Crowned Cranes during the decade. My information is as follows.

WESTERNMOST AFRICA

Senegambia. *Fig. 1* shows six regions where cranes occur; they are absent from intervening terrain because of its unsuitability for them. In the Senegal River delta and inland to Richard-Toll and Djoudj Bird National Park there are *c.* 1000 birds (G.J. Morel pers. comm.) or *c.* 2000 (B. Tréca pers. comm.), in The Gambia there are *c.* 500 (inferred from Jensen & Kirkeby 1980 and Gore 1981), and in the remainder of Senegal no more than 1000 (A.R. Dupuy, G.J. Morel pers. comm.). Seventy were recorded on the coast near Ndiol in 1971 (de Smet & van Gompel 1980).

Mauritania. P.W.P. Browne (pers. comm.) found cranes breeding on the Mauritanian side of the Senegal River delta in 1961, and from 1974 to 1981 encountered small groups, maximum 9 birds, on six occasions at Lake Aleg (17°05'N, 14°01'W), Chogar (17°20'N, 13°40'W) and at 17°25'N, 12°34'W. The population in westernmost Africa evidently numbers 2500-3500 birds.

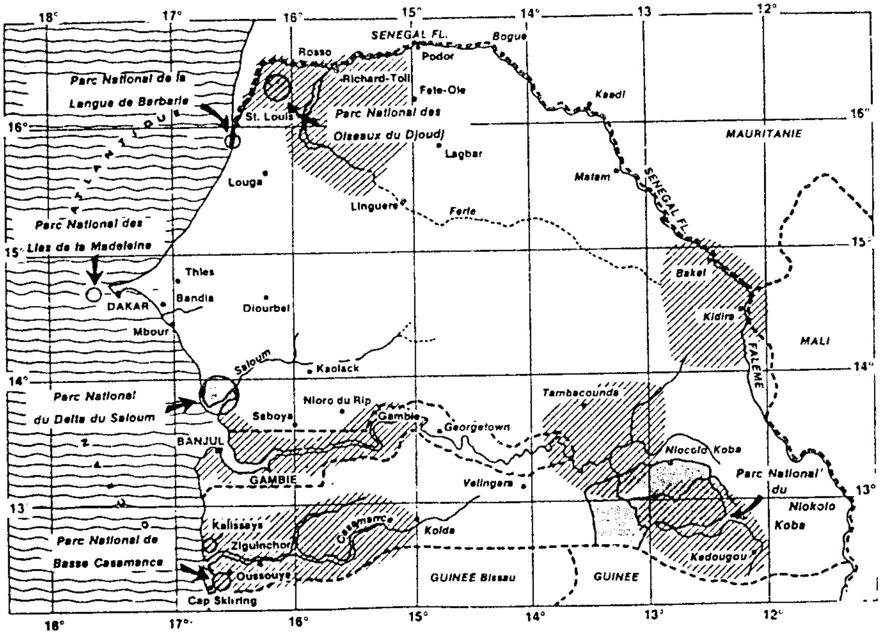

Fig. 1. Distribution of Black Crowned Crane in Senegambia (from data supplied by G.J. Morel).

GUINEA TO CAMEROON COASTAL ZONE

The species is virtually absent from West African coastal rain forest and derived savanna zones south of lat. 12°N west of Ghana and lat. 8°N east of Ghana. There are no records for Guinea (D. Richards pers. comm.) or Liberia. In Sierra Leone there were small numbers in the 1930s on the Scarcies River estuary (April, July, October-December), but subsequently the species has not been recorded at all (L. Grimes pers. comm.). In Ivory Coast the Crowned Crane is a vagrant in the extreme north (J.M. Thiollay pers. comm.). In Ghana it has been recorded recently only in Mole National Park, in small numbers by several observers in the 1960s and by R.B. Payne in 1975 (Greig-Smith 1976). It has been recorded in Togo by Dekeyser (1951), but in recent years only two solitary birds have been seen (Cheke & Walsh 1980). Cranes occur in Benin and Cameroon only near the northern borders and in Nigeria now rarely except perhaps in the far northeast (see below).

NIGER RIVER PLAINS

Mali. Lamarche (1980) found them to be common in the Middle Delta of the Niger River, and quite widely distributed on permanent marshland in the Sahelian zone of Mali, breeding in November-January. Pairs and small groups occur in the delta during the rains, concentrating in flocks of 100-250 in the dry season. J.M. Thiollay (pers. comm.) also finds them widespread, but sparse. In a helicopter survey of the delta in 1974, B. Tréca (pers. comm.) counted 271 cranes in 2.5h flying time, but in a further aerial census between Djenne and Lake Debbo in 1982 he found only 25-30. R.T. Wilson (pers. comm.) saw two flocks of 50 and 70 in the delta in February 1978 and regards the bird as uncommon elsewhere in Mali. In 600km² of land north and south of Niono (14°15′N, 05°55′W), a rice-growing area, he has only one record, of two birds, in the five years up to 1983.

Upper Volta/Benin. Crowned Cranes are frequent and breed in the Pendjari River valley which forms the national frontier (Upper Volta, Arli National Park; Benin, Pendjari National Park) and is tributary to the Niger River (Green & Sayer 1979). Largest flocks were of 60, in February and May (A.A. Green pers. comm.), and J.F. Walsh (pers. comm.) recorded 50-100 altogether in the Pendjari valley in May 1977 and July 1979. They do not occur elsewhere in Benin, but are distributed sparingly in reserves and parks in southeast upper Volta (e.g. Po National Park 120km south of Ouagadougou, A.A. Green pers. comm.). Similarly, in northern Upper Volta they are widespread but uncommon, with flocks of up to 20 around shallow lakes in the Dori-Markoye-Oursi region. Before they are able to fly young birds are taken captive by villagers in the Kantchari-Macalondi area (J.M. Thiollay pers. comm.).

Niger. Widespread in small numbers along the Niger River floodplain, at least at high water, from the Mali border (Ansongo) to some 50km south of Niamey (J.M. Thiollay pers. comm.). Some birds probably breed near the northern border of W National Park. J. Newby (pers. comm.) remarks an apparent association of Black Crowned Cranes with the increasing area of irrigated land being established for cereal cultivation along the left bank of the Niger downstream of Niamey. There is a potential risk to the birds arising from the sensitivity of the authorities about crop losses to predators; it is also possible that cranes are being adversely affected by crop-spraying operations (J. Newby pers. comm.).

Cranes are sparsely distributed on shallow lakes in drainage areas of southern Niger between Maradi and Zinder, with fewer between Maradi and Niamey (J.M. Thiollay pers. comm.). There are likely to be low hundreds in southeast Niger, close to Lake Chad (J. Newby pers. comm.).

In the opinion of J.M. Thiollay, there are probably no more than a very few thousand Black Crowned Cranes altogether in the vast extent of Mali, Upper Volta, and Niger.

NIGERIA

The species was formerly widespread throughout Nigeria north of the Niger and Benue Rivers; cranes were found more or less commonly in seven principal areas (*Fig. 2, nos. 1-7*). I estimate that in the 1960s, areas 1, 2, 3, and 6 each held hundreds, areas 4 and 5 low thousands, and area 7 (including part of Cameroon) about ten thousand (Fry 1981).

In area 1, northern Sokoto Province, they were common in the 1950s (Dobbs 1959) but had evidently declined by the early 1970s (Mundy & Cook 1971), and I am not aware of any record from this area in the last 15 years. In area 2, Kaduna-Niger valleys, I failed to find any in 1979 or 1981. In area 3, the Jos-Benue Plateau, where not long ago cranes were common, R.E. Sharland (pers. comm.) has failed to find any during several recent visits. None has been seen in Yankari National Park for many years (Crick & Marshall 1981). I have no up-to-date information for area 4. Sharland has also seen no cranes in area 5, the Hadejia-Nguru wetlands of the Komadugu Gana River, since a flock of *c.* 50 in January 1977, despite searching on several recent occasions. Two or three birds were noted northeast of Nguru in 1975 (Hall 1976b). There are no recent reports from area 6, Mallamfatori. Crowned Cranes reach their greatest West African concentrations in the plains and wetlands south of Lake Chad, in Nigerian area 7, easternmost Borno State, and adjacent northern Cameroon from Waza to Gambaru. In the wet season they are widespread, and during the dry season concentrate in Cameroon, in swamps near Logomani (*c.* 200 birds) on the Gambaru irrigation scheme, and in marshes bordering Waza National Park, where there were *c.* 10,000 in February 1972 (Holmes 1972). In area 7, cranes occur west to Lake Alo, where up to 25 winter (Hall 1977). R. Wilkinson (pers. comm.) saw 11 at New Marte in January 1982.

The cause of decline of Crowned Cranes in Nigeria is wetland modification. There have been extensive land drainage schemes on the Jos-Benue Plateau; and major changes in surface-water availability, drainage patterns and water-table levels have occurred

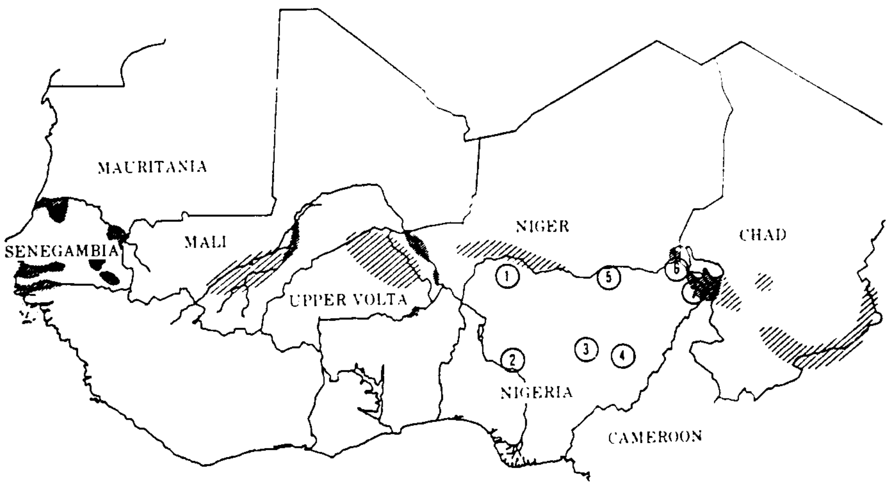

Fig. 2. Distribution of Black Crowned Crane in West Africa. Fine hatching: common; coarse hatching: sparse. Nos. 1-7: see text.

throughout the Komadugu Gana catchment and elsewhere in all northern States, in association with developing irrigated wheat schemes. For the whole of Kano State, Sharland & Wilkinson (1981) have been able to find records only from Kirikasama, in area 5, where they give the status of the species as "now rare." Indeed, R. Wilkinson (pers. comm.) has seen none in several recent visits to Kirikasama. Some may also occur in Baturiya Reserve where they are illegally hunted (or were until very recently). Crowned Cranes *still* appear for sale in Kano bird markets, despite being a First Schedule 'Prohibited' species (Hall 1976a).

The Black Crowned Crane, national bird of Nigeria, emblem of the Federal Government, symbol of the Nigerian Ornithologists' Society, is evidently on the verge of extinction in that country.

NORTH CENTRAL AFRICA

Cameroon. See above. The most recent estimate is of 7000 at Waza (Pettet 1976). Kavanagh (1977) found them abundant in 1974 and 1975 in Waza and Kalamaloue National Parks (the latter near Ndjamena). M. Louette (pers. comm.) knows of no habitat modifications in northern Cameroon that might be detrimental to the species.

Central African Republic. Sparce but probably widespread in the north; small numbers recorded in 1981 in Bamingui-Bangoran and Manovo-Gounda-Saint Floris National Parks (A.A. Green pers. comm.).

Chad. No information further to Fry (1981), except that cranes are widespread but uncommon breeding visitors to the Ouadi Rime-Ouadi Achim Reserve (Newby 1979).

Sudan (Darfur). The only recent records are of 500-700 birds on Lake Kundi, Bahr el Arab at 25°15′E, during the winter dry seasons of 1972-3 and 1973-4, and 250-300 close to the Chad border at 12°10′N, 22°40′E in December 1976 (Wilson 1982 and pers. comm.).

ACKNOWLEDGEMENTS

For providing me with recent information on the status of cranes in parts of West Africa known to them I am much indebted to P.W.P. Browne, H.Q.P. Crick, A.R. Dupuy, G.D. Field, A.A. Green, L. Grimes, P. Hall, B. Lamarche, M. Louette, G.J. Morel, J.E. Newby, G. Nikolaus, D.K. Richards, R.E. Sharland, J.M. Thiollay, B. Tréca, J.F. Walsh, R. Wilkinson, and R.T. Wilson.

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RAINY SEASON ECOLOGY OF SOUTH AFRICAN GREY CROWNED CRANES IN THE LUANGWA VALLEY, ZAMBIA

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ABSTRACT

The ecology of South African Grey Crowned Cranes (*Balearica regulorum regulorum*) was studied at a $4km^2$ study area in Chichele Plain, a floodplain of the Luangwa River in eastern Zambia. Observations were made between 1 December 1978 - 20 February 1979 with two intensive study periods. Behavior and habitat use are described. A gradual increase in breeding behavior was observed after initiation of the rains in mid-December.

INTRODUCTION

South African Grey Crowned Cranes (*Balearica regulorum regulorum*) range south of 8°S in suitable habitats on continental Africa. Commonly displayed in zoos throughout the world and widely known for its striking appearance, only scant information is available about this crane in the wild. Walkinshaw (1964, 1973) provides the only information on this race. During the 1978-1979 rainy season I studied a population of Grey Crowned Cranes inhabiting a floodplain in the Luangwa Valley, Zambia.

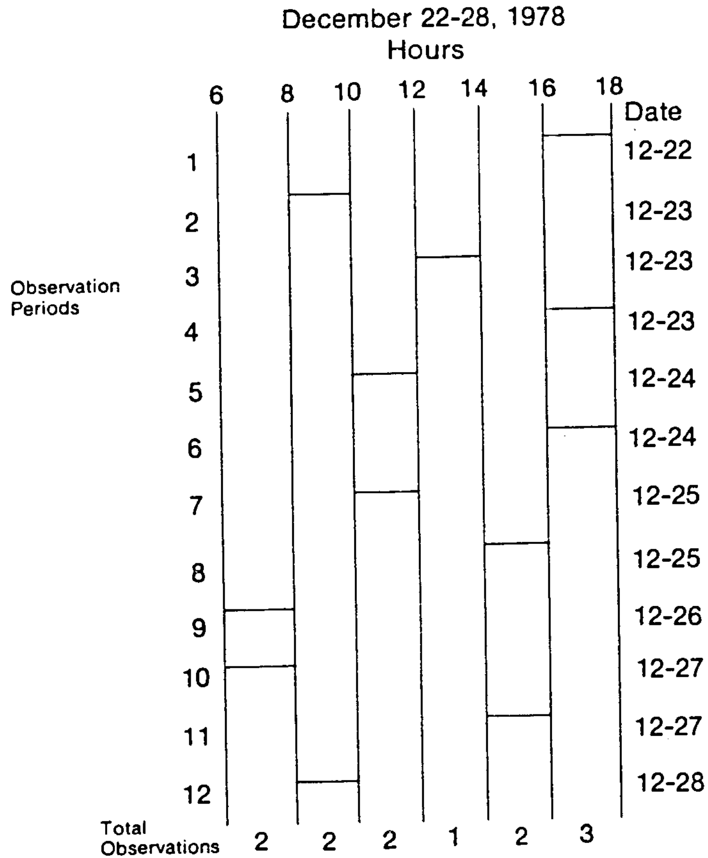
Field studies describing other crowned crane populations include Pomeroy (1980) on *B. r. gibbericeps* in Uganda, Urban and Walkinshaw (1967) and Urban (1981) on *B. p. pavonina ceciliae*, and Fry (1981) on *B. p. pavonina*. Walkinshaw (1964, 1973) provides information on all four crowned crane subspecies.

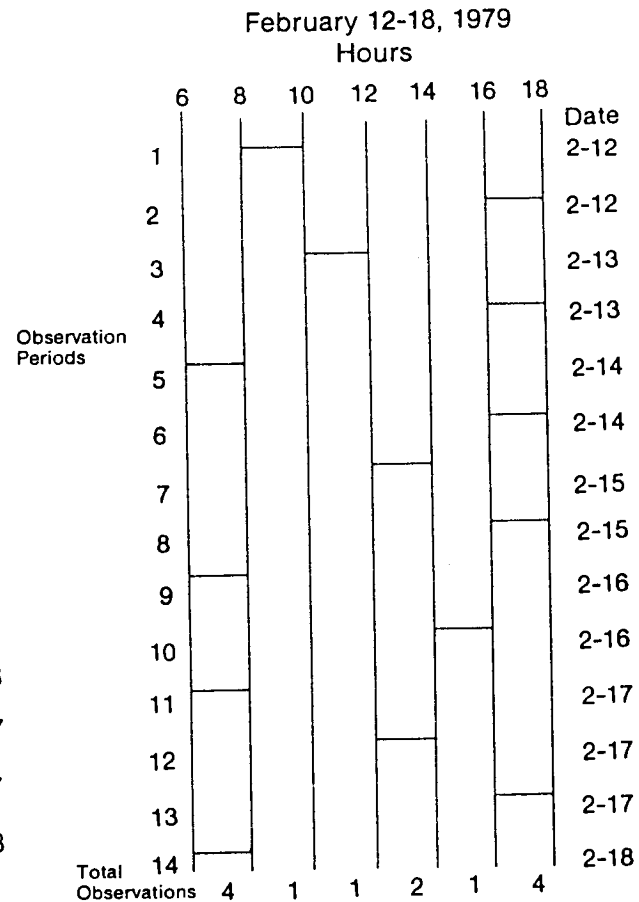
To describe some aspects of the life history of South African Crowned Cranes and to provide insight into the wildlife community they represent, I collected data on animal species, numbers, and behavior during daylight observation periods at Chichele Plain, in Luangwa Valley, Zambia. During two periods of intensive study, 22-28 December 1978 and 12-18 February 1979, 26 two-hour study periods were scheduled to make detailed observations (*Table 1*). General observations were made 1-3 December 1978 and between the two-hour study periods in December and February.

STUDY AREA

The Luangwa Valley was formed as the drainage trough of the Luangwa River between the Muchinga Escarpment and the Nyika Plateau, flowing through eastern Zambia to join the Zambezi River (*Fig. 1*). Numerous sandbars and sand beaches are formed along the Luangwa's meandering course through tropical woodlands. The Luangwa River's

Table 1. Time schedule for December and February observation periods.





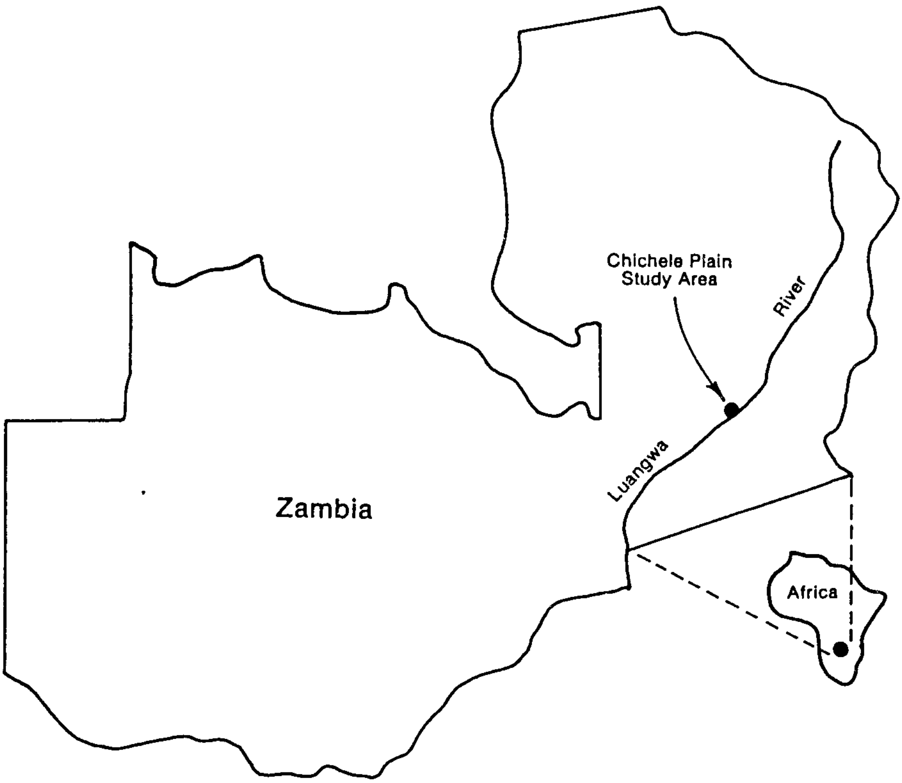


Fig. 1. Location of Chichele Plain Study Area.

floodplain is characterized by level plains formed in low lying areas adjoining the river.

The Luangwa Valley has a tropical climate. Annual temperatures average 40°C, ranging from 28°C to 56°C; 110cm of rain falls mainly from November to April, during the Austral summer. Humidity is high during the rainy season.

The Chichele Plain, is located along the Luangwa River just south of its confluence with Chichele Stream, encompassing approximately 4km². In addition to the river system, other habitats included a riparian floodplain with a predominantly grass sedge plant community bordered by riverine and gallery woodlands and one area of shrub like elephant browsed trees (*Fig. 2*). Chichele Plain floods seasonally; only minimal flooding occurred during the 1978-79 rainy season, in contrast to 1977-78 when the entire study area was inundated (Francis Phiri, pers. comm.).

Chichele Plain supports a diverse and abundant wildlife community and is included in South Luangwa National Park. During the rainy season, wildlife is generally widely dispersed, because water, green vegetation, and other food sources are plentiful throughout the valley. However, it should be noted that during the dry season many wildlife species are concentrated at or near the Luangwa River because it is one of the few water sources in the valley at that time. Consequently, wildlife species composition, numbers, and habitat use change throughout the annual cycle.

BEHAVIOR

Benson et al. (1973) describe the Grey Crowned Crane as particularly common in the Luangwa Valley. They were among the most numerous birds in the Chichele Plain study

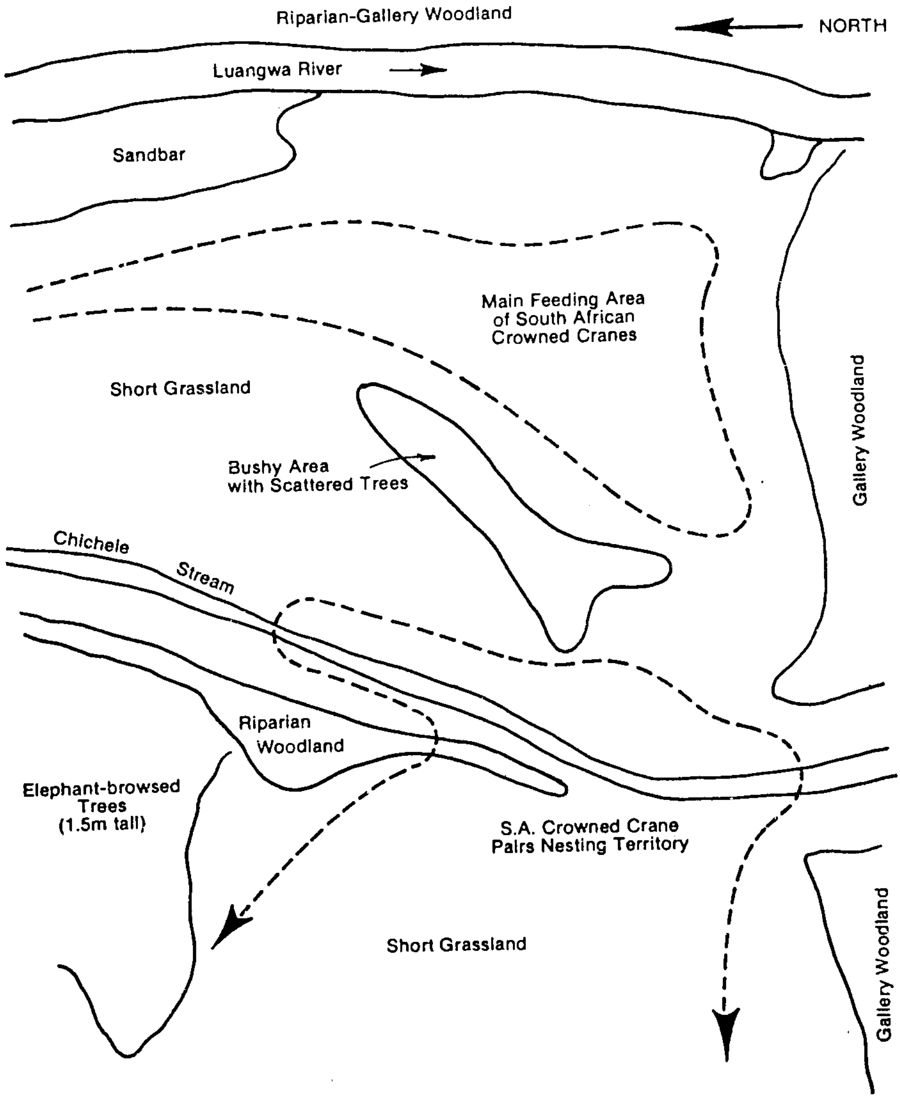


*Fig. 2.*Chichele Plain study area habitat.

area. A population of up to 64 used the floodplain during daylight hours. The cranes arrived most mornings about sunrise (0600 hours) in several flocks numbering 2 to 24. They fed in the open grasslands of the floodplain east of Chichele Stream in the company of a variety of wildlife until near sunset (1820 hours), when they flew north along the Luangwa River to their roosting area.

The number of cranes using the study area varied throughout the day and daily. Numbers of crowned cranes using Chichele Plain increased from December to February (*Tables 2* and *3*). Flock size was noted 162 times; it varied from 1 to 54 individuals. Associations of 2 cranes were most frequent (41 times; 25%) and in most cases probably represented mated pairs. One hundred fourteen flocks contained 10 cranes or less (68%). Only 27 flocks included more than 20 cranes (17%).

Table 2. Abundance of primary species and total animals seen during December observation periods.

	December														
	1	2	3	4	5	6	7	8	9	10	11	12	Total	Mean	Mean Density/ km^2
South African Crowned Crane	41	28	1	5	24	3	26	31	17	19	30	33	258	21.5	5.4
Egyptian Goose	15	16	4	24	23	10	32	23	25	11	15	11	209	17.4	4.6
Spur-winged Goose	2	13	12	12	2	20	26	21	26	0	0	12	149	12.4	3.1
Puku	36	55	40	40	36	35	22	13	44	62	20	24	427	35.5	8.9
Olive Baboon	0	100	0	0	35	0	38	5	120	6	0	0	304	25.3	6.3
Impala	1	0	5	0	2	29	30	0	14	9	10	14	114	9.5	2.4
African Hippo	20	27	10	12	21	11	15	17	22	25	26	18	224	18.7	4.7
African Elephant	1	2	0	0	1	0	0	3	6	12	0	2	27	2.2	0.5
Total Animals*	132	260	76	144	167	112	205	121	275	159	134	131			Total 1,843

*Includes all birds, mammals, and crocodiles observed.

Table 3. Abundance of primary species and total animals seen during February observation periods.

	February																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Mean	Mean Density/ km^2
South African Crowned Crane	57	46	49	64	48	54	30	19	46	17	60	5	19	21	535	38.2	9.5
Egyptian Goose	86	150	17	107	30	36	66	23	50	48	140	61	91	81	986	70.4	17.6
Spur-winged Goose	3	1	0	1	8	0	4	12	4	7	4	7	8	2	61	4.4	1.1
Puku	96	26	65	49	58	32	33	40	47	25	68	12	58	83	692	49.2	12.3
Olive Baboon	11	0	96	0	50	3	22	10	91	19	53	5	9	96	465	33.2	8.3
Impala	58	33	44	66	52	29	44	18	48	32	29	24	2	35	514	36.7	9.2
African Hippo	28	16	24	19	15	12	23	12	19	27	16	15	10	18	254	18.1	4.5
African Elephant	0	3	1	1	0	0	8	13	4	11	7	15	0	0	63	4.5	1.1
Total Animals*	643	285	318	336	289	176	274	159	350	204	409	148	302	553			Total 4,445

*Includes all birds, mammals, and crocodiles observed.

The cranes fed on grass seeds by grasping the grass stem with the bill and stripping the seed head with an upward stroke of the neck, head, and bill. This process was repeated over and over while walking across the plain. Insects and other food items were captured and eaten while walking. Another method used to locate insect prey was to stamp the feet up and down in grass; as insects were flushed the cranes attempted capture. The cranes moved from one area to another using this method. This behavior was also noted for Grey Crowned Cranes in Uganda (Pomeroy 1980), and I observed Secretary Birds (*Sagittarius serpentarius*) doing the same thing in the montane grasslands of Natal, South Africa.

After heavy or prolonged rains, an area of low floodplain was inundated by shallow (15cm) standing water. During these temporary flooded conditions, the cranes fed mostly along the waters perimeter, where they pecked at food, presumably insects and other invertebrates disturbed, trapped, or attracted by the water. They continued feeding during rain showers.

Cranes were almost always observed in open, flat terrain with short vegetation, where they had an unobstructed view of the surrounding area. Their height (1.4m) allows a good view for potential predators. Also, they are usually seen in close association with Puku (*Kobus vardoni*), Impala (*Aepyceros melampus*), Olive Baboons (*Papio cynocephalus*), Zebra (*Equus burchelli*) Spur-winged Geese (*Plectropterus gambensis*), and Egyptian Geese (*Alopochen aegyptian*), which also fed on the open grasslands. These associations are surely of benefit to all species in detecting threats. More eyes at several heights and directions, the acute senses of smell and hearing of the mammals, and flight and perching abilities of the birds combine for cooperative security. Man was the only potential predator to approach the crowned cranes closely. The birds reacted to the fishermen by bunching into a close flock. Predation of a crowned crane by a Nile Crocodile (*Crocodilus niloticus*) was observed in the Luangwa Valley by John Hazam (pers. comm.).

Occasionally south African Crowned Cranes perched in tall (i.e. 20m), dead trees with bare limbs and an open vantage point. The perch site was usually in the topmost branch. When two birds perched together they selected different branches atop the same tree. One morning 5 crowned cranes perched in a tall, dead tree. Perching in trees was observed after heavy rains during the rainy season. Upon landing and grasping the branch with their feet, it was often necessary to balance themselves with their wings held outstretched until stable. Once perched, they rest and observe, or preen, calling occasionally.

Bathing was observed during hot, cloudless afternoons. The cranes bathed for up to 3 hours. Other wildlife either left the plain for the shade of the forest or likewise bathed.

The breeding biology of South African Crowned Cranes is closely associated with the rainy season (Walkinshaw 1973; Benson et al. 1973), which occurs from November to April in the Luangwa Valley. I observed a marked increase in breeding behavior in the crowned cranes at Chichele Plain between December and February. The amount of sexual behavior including booming (unison calling between mating pairs), allopreening (ritualized facial preening), and dancing increased in the flocks visiting the plain, although these behaviors were not quantified. Communal dancing among members of a flock of 60 cranes was observed 17 February.

The increase in breeding behavior in February was exemplified by a pair that used a part of the study area along Chichele Stream as the eastern limit of its nesting territory. During December, this pair was seen during 5 of 12 observation periods, while in February the pair or a single crane was in attendance during 11 of 14 observation periods.

On 12 February this pair was very territorial, flying over the perimeter of their territory displaying the large white wing patches and calling. They perched atop tall, dead trees periodically during territorial flights, calling loudly across the plain: *Owan-Owan-Owan....* The pair danced together periodically and were observed copulating once. The following day, only a single crane arrived at Chichele Stream, actively flying, perching, and calling territorially. On 14 February both cranes were observed near Chichele Stream with one bird flying, perching, and calling territorially. On 15 February, a single crane was observed on territory, but both birds were in attendance the following three days. One crowned crane was observed flying and calling territorially on 18 February. Observations of copulation and single cranes on territory indicated this pair was in the early stages of egg laying and incubation. Behavior of the pair indicated the nesting and roosting sites were west of the study area. South African Crowned Cranes usually nest in tall bullrush stands or similar wetland vegetation, and no habitat of this type was available in the study area.

During the February study period one pair with two downy chicks less than 10 days old were seen approximately 4km north of the study area in a grassland plain bordering a wetland. This pair nested in January. Benson et al. (1973) provide nesting dates for South African Crowned Cranes from December through April in Zambia (generally during the rainy season). However, no records are given specifically for the Luangwa Valley.

Other wetlands I visited in Zambia in 1978-79 inhabited by large Grey Crowned Crane populations were Liuwa Plain in Western Province, Busanga Plain in Northwestern Province, and Kafue Flats in Southern Province. Each of these wetlands is a large, riparian floodplain.

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THE STATUS OF CRANES IN ZIMBABWE

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ABSTRACT

Two cranes occur in Zimbabwe, the Wattled Crane (*Bugeranus carunculatus*) and the Grey Crowned Crane (*Balearica regulorum*). Both are fully protected, but their future is tied to the continuance of large scale commercial agriculture, which provides suitable habitat free of disturbance.

Two species of cranes occur in Zimbabwe, the Wattled Crane (*Bugeranus carunculatus*) and the Southern or Grey Crowned Crane (*Balearica regulorum*). Both are designated Royal Game in terms of the Zimbabwe Wildlife Act and they and their nests are fully protected. Since 1979 the two species have been included in the Selected Species Survey of the Ornithological Association of Zimbabwe and thus have been given special attention in regard to sight and breeding records.

GREY CROWNED CRANE

This is by far the commoner of the two species and can even be seen in fields and open spaces in and around the main urban areas. Flocks of up to hundreds are fairly frequent, particularly during the dry season (May to November), when the cranes are not breeding. At Rainham Dam near Harare, they are frequently found in the shallower, weedier areas of the dam as well as on the grasslands below it. *Fig. 1* shows the distribution and breeding of the Crowned Crane in Zimbabwe. Records are taken from the Selected Species Survey, the Field Card Scheme and the Nest Record Cards, all ongoing projects of the Ornithological Association of Zimbabwe.

With the coming of independence and the upsurge of peasant farming Crowned Cranes have been reported as becoming agricultural pests. In western Matabeleland a rice-growing enterprise has been plagued by flocks of over 200 cranes which are destroying the rice at various stages of development. The Department of National Parks and Wildlife Management has been given the task of dealing with a problem animal which is also Royal Game. At this time nothing has been done because of a precarious security situation in the area.

As can be seen from the map the Crowned Crane is confined to land over 1000m and they are not generally found in the low lying river valleys. They have adapted well to agriculture, particularly in the commercial farming areas where there has been a proliferation of small dams for irrigation purposes. Indeed, these small dams form the major breeding habitat for both species of cranes in Zimbabwe.

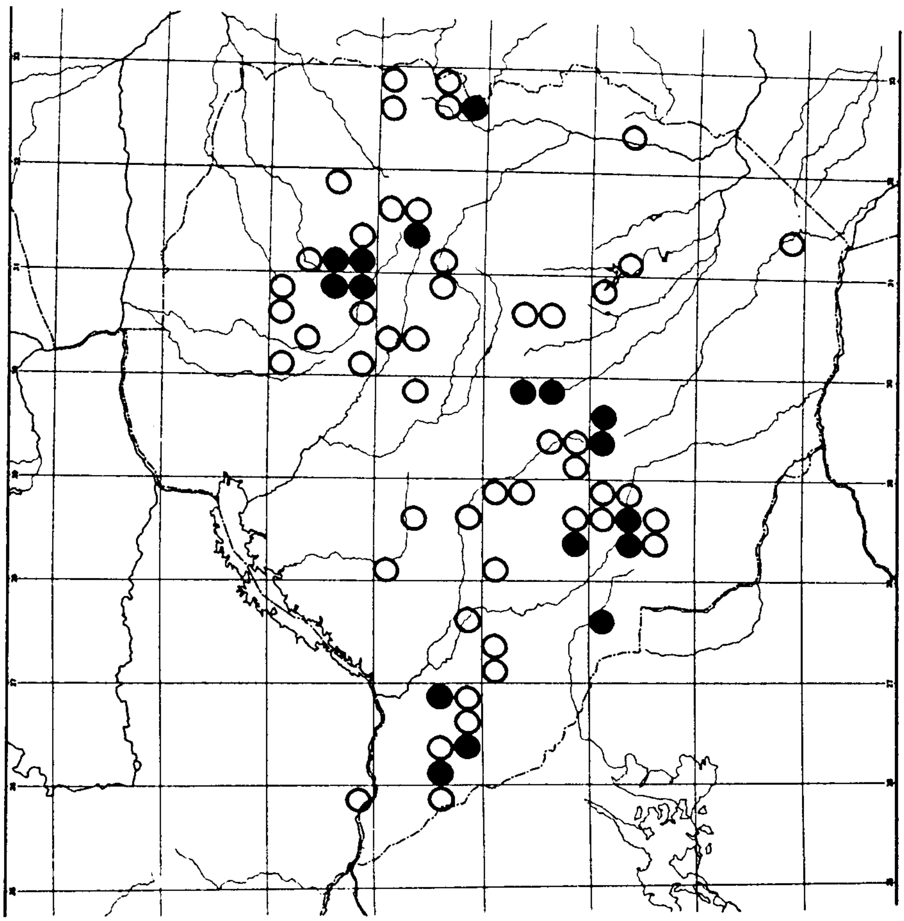

Fig. 1. Crowned Crane. Distribution of Crowned Crane in Zimbabwe. o denotes sight record; • denotes breeding record.

WATTLED CRANE

This is the rarer of the two species and is also more confined in distribution (*Fig. 2*), being present in land over 1500m and is thus mostly to be found in the east of the country. It is probably most common in the Eastern Districts of Zimbabwe where it is found on submontane downland at altitudes of over 2000m. Contrary to the situation with the Crowned Crane the Wattled Crane breeds during the dry season from April to September although records occur throughout the year (Irwin 1981). The Wattled Crane seems to be involved in some movement in Central Africa but this is as yet little understood. There seems to be a westward movement during the rains and probably involves contact with the western Zambian population where flocks of 80 and more have been seen in April. Nonbreeding flocks of up to 77 Wattled Cranes have been seen quite often in the Harare area at Rainham Dam/Gwebi Flats where they congregate on inundated grassland below the dam wall.

BLUE CRANE (*Anthropoides paradisea*)

There are several accidental records of this species in the country although these are unconfirmed. The possibility of wanderers from South Africa cannot be ruled out.

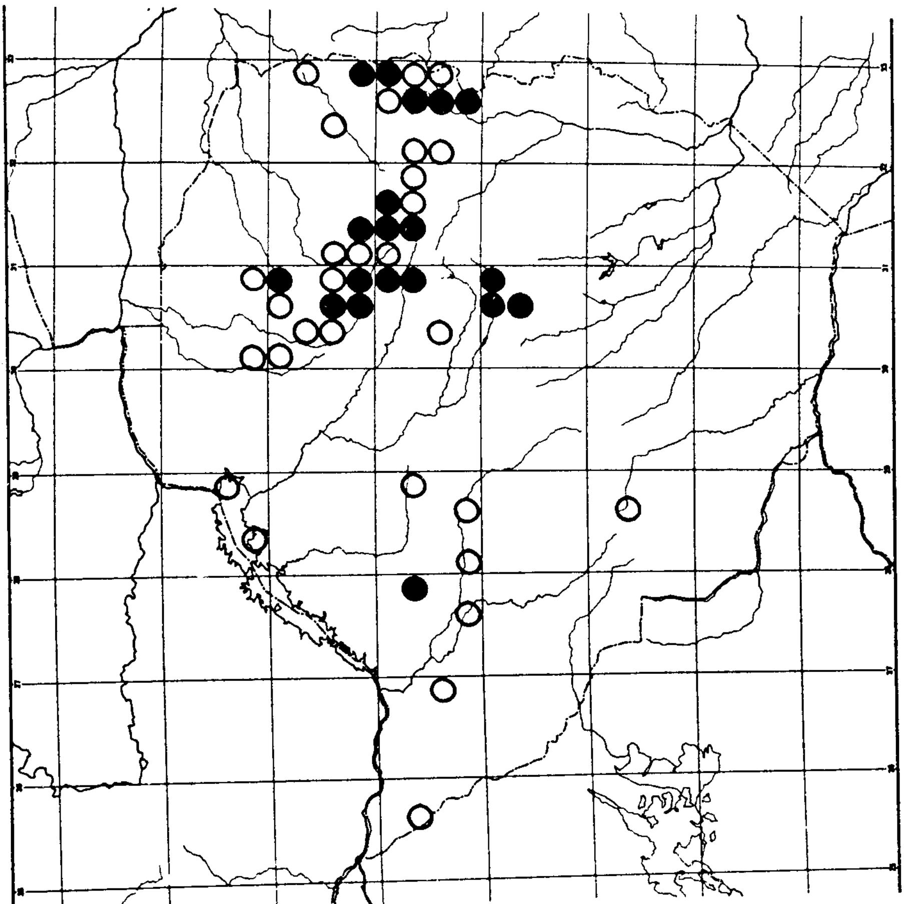

Fig. 2. Wattled Crane. Distribution of Wattle Crane in Zimbabwe. o denotes sight record; • denotes breeding record.

CRANES IN CAPTIVITY

Larvon Bird Gardens outside Harare has 2 breeding pairs of Crowned Cranes and these both produced young this year. The younger pair produced one young but the older, more experienced pair produced four. An initial clutch of two was successfully hatched and at about two weeks of age the male took care of these while the female laid another two eggs and successfully hatched them. One of the later chicks, the smaller, subsequently died following a period of cool weather. There are also two adult Wattled Cranes at the gardens and it is obvious that these are of the same sex as no courtship has been observed. All the cranes are in large open topped aviaries and are consequently pinioned on one wing including the four Blue Cranes also present. Both indigenous species call to conspecifics when they fly into the nearby grassland. On one occasion a wild Crowned Crane joined a family group in an enclosure although was quickly evicted by the residents.

WETLAND CONSERVATION

Zimbabwe is not yet a party to the Ramsar Convention on the conservation of wetlands and although there are few major wetlands in the country and none of international importance, this situation should be rectified. Increasing peasant agriculture and population pressure may pose a threat to the few wetlands that exist. These are mostly in the form of seasonally flooded grasslands called vleis, pans, which are shallow natural depressions, also seasonally flooded, and riverine floodplains which are threatened by hydroelectric development. Only the first two habitats are utilized by cranes. If commercial agriculture, which involves large well-organized farms with many dams for irrigation and water storage, can be maintained the state of the cranes will be secure, but if badly controlled peasant agriculture with the evils of overstocking, soil erosion and excess population and disturbance is allowed to proliferate indiscriminately the future of the cranes will be in jeopardy. Contrary to most of the Royal Game species in Zimbabwe cranes are not commonly found in our famous National Parks which are mostly situated in the major river valleys so the future of the cranes depends on the continuance of well-organized commercial agriculture. There is little evidence of the illegal hunting of cranes other than the occasional retaliation for crop raiding. A few of the cranes and other species at Larvon Bird Gardens are powerline casualties, but fortunately there are not that many powerlines in Zimbabwe.

FUTURE CRANE RESEARCH

An intensive survey must be carried out into the status of the Wattled Crane in Zimbabwe. It is believed that some flying time for an aerial survey of cranes has been allocated by the Department of National Parks and Wildlife Management. This offer should be taken advantage of while the cranes are breeding and also conspicuous during the dry season. Both crane species will remain on the Selected Species Survey of the Ornithological Association and it is also hoped that we can obtain a breeding pair of Wattled Cranes for Larvon Bird Gardens.

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WATTLED CRANES IN PERIL - KAFUE FLATS, ZAMBIA

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ABSTRACT

The range and population size of the Wattled Crane (*Bugeranus carunculatus*) is shrinking in southern Africa. The Kafue Flats, a large wetland in Zambia, supports the world's largest Wattled Crane population. However, a hydroelectric power development built in the 1970s may threaten the future of these cranes. Other wildlife, the fishing and cattle industries, and resident people will also be affected. Suggestions are made to organize a meeting of all interested parties to reevaluate water management in the Kafue Flats.

The historic range of the Wattled Crane (*Bugeranus carunculatus*) is shrinking due to habitat alteration in Africa by modern man. Concern has been generated for the future of this majestic bird. Already Wattled Cranes have vanished from areas formerly inhabited in Cape Province, South Africa (West 1976, 1977) and Swaziland (Ted Reilly, pers. comm.). The species is also listed as endangered in the remaining provinces in South Africa (Siegfried et al. 1976). It is also declining in numbers or scarce throughout the remaining range in southern Africa and Ethiopia (West 1976, 1977). Only an estimated 6000 Wattled Cranes remain in Africa today.

The stronghold for Wattled Cranes is an area in southcentral Africa within the borders of Zambia and in northern Botswana (Konrad 1981). There, large numbers of Wattled Cranes can still be seen in certain extensive wetlands. Wattled Cranes have specialized habitat requirements, using shallow wetlands to nest, roost, and feed on sedge tubers and rhizomes.

Research projects completed during the 1970s indentified the Kafue Flats, a large riparian floodplain formed along the Kafue River in Zambia, as the single most important wetland for Wattled Cranes (Douthwaite 1974, Konrad 1981). As many as 3000 Wattled Cranes (one-half the total population) inhabit this wetland during flood drawdown (June through November). In years of adequate flooding 300 pairs nest (Douthwaite 1974). Each nesting pair requires a large area of shallow water for its nesting territory, measuring 1km² or more in size.

Measuring 255km long and covering 6000km², the Kafue Flats has been described as one of Africa's greatest wetlands. Its importance is reflected by the fishing, pastoral, mining, agricultural, hydroelectric, wildlife, and tourist industries.

The natural ecology follows the annual flooding-drying cycle. Historically, the flooding began with the start of the seasonal rains in November. Greatest water volumes originated in the upper Kafue River Basin where rainfall is higher. Flooding peaked in the Kafue Flats between March and June, with floodwaters receding slowly until November when

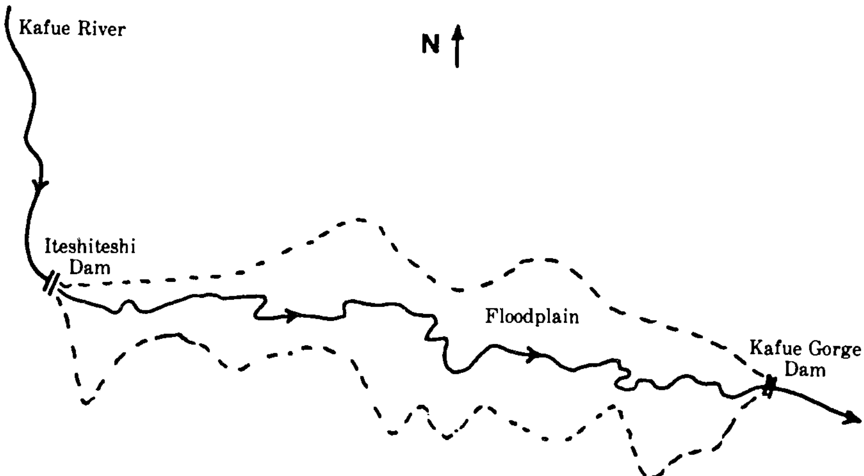

Fig. 1. Kafue Flats, Zambia.

the cycle resumed. However, during the 1970s a large hydroelectric scheme was built that drastically altered the flooding ecology of the Kafue Flats. Dams were built on each end of the Kafue Flats for production of hydroelectric power (*Fig. 1*). The dam at the upstream end of the Kafue River, Iteshiteshi Dam, was built to hold floodwaters in its reservoir and release water to provide more uniform flow through the wetland throughout the year, providing a steady water supply for hydroelectric production at Iteshiteshi and at the Kafue Gorge Dam downstream. This permanently floods a greater area and reduces the area seasonally flooded, shrinking the area of the floodplain (Williams 1977).

Plant and animal life, including man, have adapted to the natural flooding regime; these organisms and their annual production will, therefore, be reduced relative to the reduction of the floodplain's area. Researchers predicted a negative effect upon Wattled Cranes (Douthwaite 1974, Konrad 1981), Kafue Lechwe (Schuster 1977), and other wildlife (Sheppe & Osborne 1971). Already aerial censuses show a dramatic decline of 50-60% in Kafue Lechwe numbers since present water management policy was initiated on the Kafue Flats in 1977 (Wildlife Conservation Society of Zambia, pers. comm.). This has caused national and international concern. The Kafue Lechwe population crash appears to be a response to the new lowered carrying capacity of the floodplain habitat. It can be predicted the Wattled Crane population may likewise crash due to constricted feeding areas and limited nesting sites. Cranes are long-lived birds, therefore former numbers may persist for 15 years; a lower recruitment will eventually decrease the population size. In 1978, only 3.6% of the Wattled Cranes observed at the Kafue Flats were juveniles (Konrad 1981), probably already a response to the altered flooding regimen.

The negative effect of the present water management policy will also cause a decline in the fishing industry centered in the Kafue Flats. Before present water policy was implemented up to one-quarter of the total annual fish production in Zambia came from the Kafue Flats (Handlos 1977). However, because fish spawn in the shallow floodwaters and nearly all fish are caught by gill netting in water less than two meters deep, researchers predicted a decline in fish harvest (F.A.O. 1968). No recent information on present fish harvest is available, but the importance of fish as a source of protein to the people of Zambia cannot be underestimated. Growing human populations will require greater amounts of fish for food, placing increased demands on the fishing industry of the Kafue Flats.

The cattle industry will also decline if present water management continues. The Kafue Flats supports one of the largest cattle herds in Africa. During the critical dry season when most of the other pasturelands are dry and overgrazed or burned, herds are dependent on the vegetation of the floodplain. As floodwaters recede, grasses and sedges provide the only foods available. Because the area of floodplain is reduced, the number of cattle will be limited accordingly. This will also depress the welfare of the people of the Kafue Flats and Zambia.

Like domestic livestock, large grazing mammals will be limited by reduced floodplain pasturelands. Zebra, Wildebeast, Cape Buffalo, Eland, Roan, and Reedbuck populations will be most affected (Sheppe & Osborne 1971). Overall the natural web of life in the floodplain, wetland, and surrounding lands will decline beginning at the microscopic level with repercussions throughout the interconnected feeding hierarchies to the predatory birds and mammals and ultimately man.

In 1967, the Kafue Basin Research Project was established by the Senate of the University of Zambia to "encourage a balanced program of interdisciplinary research and to contribute to the planned development of the Kafue Basin," it was administered by the Kafue Basin Research Committee. Multidisciplinary research was planned and carried out, and the results published. In its published report the Kafue Basin Research Committee advised "KBRC believes that development plans should recognize that biological and agricultural necessities may ultimately overwhelm other factors: in particular that the biological productivity of an area such as the Kafue Flats may in the long run prove to be vastly more important to mankind than its short term value as modified water storage for generation of electrical power" (Williams & Howard 1977).

RECOMMENDATIONS

Proper regulation and timing of water discharge at Iteshiteshi Dam is of paramount importance to the future of the Kafue Flats. Water management on the Kafue Flats should be discussed and reevaluated by representatives from all interests in this wetland. Water regulation can, and should, be used to enhance the total production. Iteshiteshi Dam can be used as an effective management tool to provide floodwaters, even during years of little rain and little natural flooding, for the cumulative advantage of all interests.

Hydroelectric power generated at Iteshiteshi and Kafue Gorge Dams may be compromised for short periods annually; however, any power needed in excess of these sources can be made by using Kariba's plentiful supply. A move toward greatest productivity including all interests is required.

It is hoped the people and government of Zambia appreciate the need for reevaluation of water management policy on the Kafue Flats. It is recommended that a meeting be held of interested parties, including Zambia's Ministry of Power, Transport, and Communication; Ministry of Lands and Natural Resources; Ministry of Tourism; National Parks and Wildlife Department; Zambian Electrical Supply Corporation; Central Africa Power Corporation; Kafue Basin Research Committee; Wildlife Conservation Society of Zambia and other parties that can make a contribution of information or insight toward drafting a new comprehensive water management policy in the Kafue Flats, Zambia.

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THE WATTLED CRANE IN SOUTH AFRICA DURING 1978-1982

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INTRODUCTION

The Wattled Crane (*Grus carunculatus*) is endemic to the Afrotropical region where it occurs in a series of disjunct populations between Ethiopia and South Africa. Attention has recently focussed on the decline in the range and numbers of this species, and it has been included in the 'red data' lists for both the *African Bird Red Data Book* (Collar and Stuart 1985) and the *South African Red Data Book - Aves* (Brooke, in press). The isolated population found in South Africa (which is about 1000km from the nearest neighbouring populations in Botswana and Zimbabwe) has been the subject of several recent reviews (Walkinshaw, 1973; West, 1975; Konrad, 1981; Tarboton, 1984), but to date there has been no overall assessment of its size or reproductive status. This paper sets out to fill this gap and presents results of censuses made during 1978-1982 as part of an ongoing project being conducted by the conservation agencies of the Natal and Transvaal Provincial Administrations. Possible reasons for the decline in Wattled Cranes in South Africa have been discussed previously and are not discussed further here; instead the formation of a working group to conserve the species in South Africa is described and a proposed strategy for their conservation is outlined.

METHODS

The sedentariness, in south Africa, of Wattled Crane breeding pairs, coupled with their large size and conspicuousness both from the ground and the air, makes counting their numbers relatively easy. Unless their breeding sponges dry out, resident pairs appear to stay permanently at their sites and can be found there throughout the day and at all times of the year. Thus an accurate census of the total South African breeding population at any one time is possible simply by checking every potential breeding site (either aerially or from the ground). To date an overall synchronized count has not been made, but parts of the population have been counted at different times. The population in the Steenkampsberg has been censused the most thoroughly so far, with each breeding site here checked quarterly for occupation during 1978-1982 (details of this are given in Tarboton, in press). Elsewhere in the Transvaal all the known breeding sites have been less regularly checked from the ground (five times during 1978-1982). In Natal, a sample of breeding sites was regularly checked from the ground during 1980-1982 and between May and July 1982 every known Natal breeding site was checked at least once during aerial surveys which extended into areas of potential habitat in the Orange Free State and Transkei.

The size of the nonbreeding segment of the poulation (which are referred to as 'floaters' hereafter) is less easy to determine as these birds are mobile, often join Blue and Crowned Crane flocks and often range into areas of intensive agriculture away from breeding habitats where they are unlikely to be detected during surveys of breeding sites. For these reasons only rough estimates of the number of floaters in the opulations are available and there has been no attempt thus far to count them more systematically.

RESULTS

Distribution

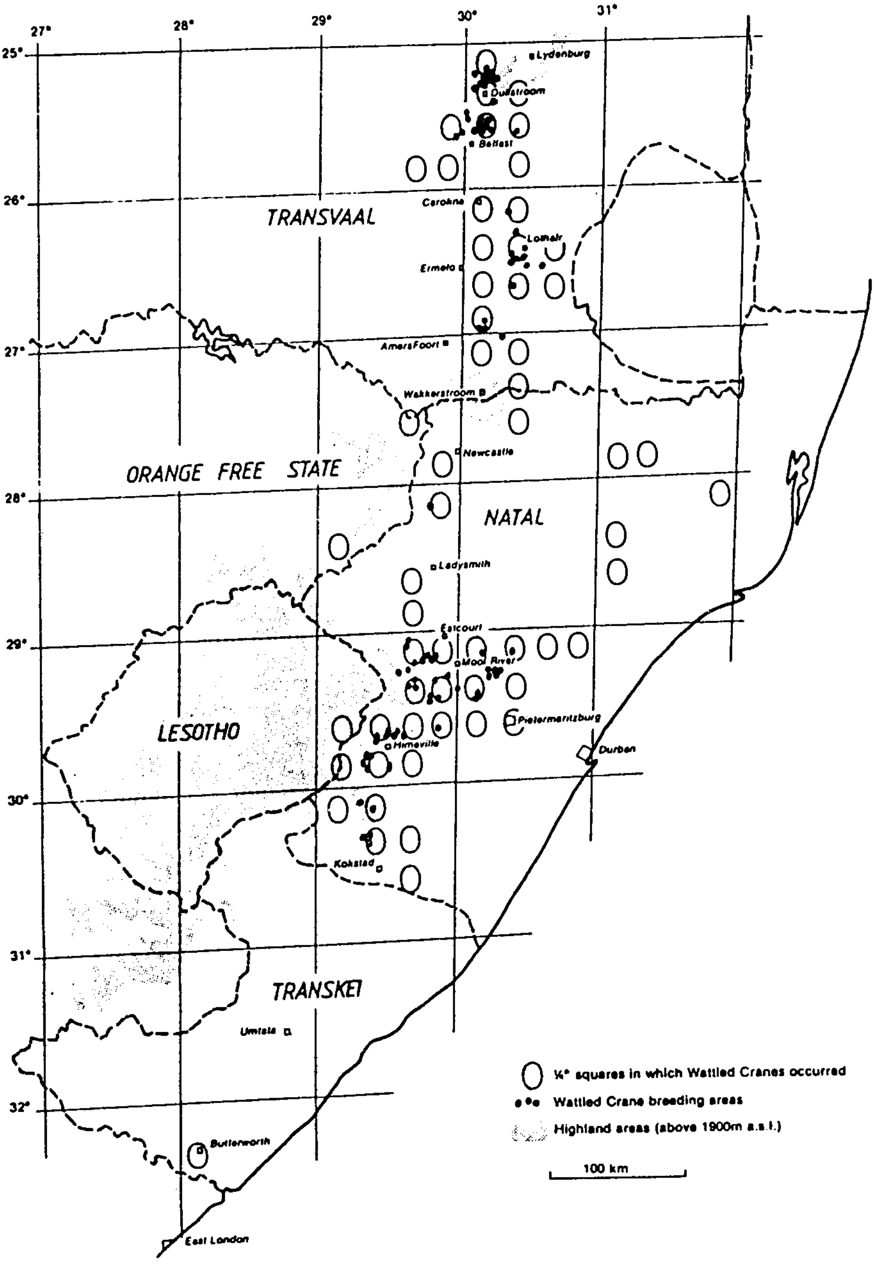
Wattled Cranes were recorded from 58 quarter degree squares in South Africa during the period 1978-1982 (Transvaal 21, Natal 34, Orange Free State 2, Transkei 1) ranging northwards from Butterworth, Transkei to Dullstroom, Transvaal over a distance of 800km (*Fig. 1*). Their breeding range was more restricted, the most southerly site being near Kokstad (latitude 30°30'S) and the most northerly near Dullstroom (latitude 25°25'S).

As shown in *Fig. 1* the breeding population is divided into two discrete subpopulations, one in Natal along the eastern foothills of the Drakensberg mountains and the other in the Transvaal in the high lying southeastern highveld. At a finer scale it can be seen that the breeding sites in these two areas are clustered into nuclei. In the Transvaal the largest nucleus is in the Steenkampsberg mountains around Belfast and Dullstroom (20 pairs) with smaller nuclei in the catchments of the Usutu River (around Lothair, 6 pairs) and the Vaal River (east of Amersfoort, 3 pairs). In Natal the main breeding nuclei are in the catchments of the Umzimkulu River, around Himeville (13 pairs), the Mooi River (11 pairs) and the Umgeni River (17 pairs). These aggregations of breeding sites reflect at least partly the distribution of permanent sponges in the area, since such sponges provide Wattled Cranes with their main breeding habitat in South Africa. The occurrence of sponges is, in turn, closely tied to the region's geomorphology and rainfall: a high rainfall and a plateau type topography results in a high incidence of sponges whereas a dissected topography with rapid water runoff is largely devoid of sponges. In Natal this is well demonstrated by comparing the topography and the number of crane pairs in the adjacent catchment areas of the Umkomaas River (high relief, no breeding Wattled Cranes) and the Umzimkulu River (low relief, 13 breeding sites). On a wider scale, the dearth of breeding Wattled Cranes in the intervening area between Natal and Transvaal populations is partly attributable to the unfavourable geomorphology of the area and the consequent scarcity of permanent sponges.

Nonbreeding birds, usually singletons, but less frequently pairs or small flocks, may range hundreds of kilometers beyond the present breeding range, e.g. to southern Transkei, northeastern Natal and eastern Orange Free State, as shown in *Fig. 1.*

Population Structure

Three age classes of Wattled Cranes are recognizable in the field: adults (more than 12 months old, having grey crowns), immatures (4-12 months old, having white crowns and reduced wattle size) and juveniles (less than four months old and not yet flying). (The adults implied above are not necessarily sexually mature). In the Steenkampsberg the total number of Wattled Cranes present and the ratio of adults:immatures:juveniles did not



27°
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Dullstroom
Belfast
Carolina
TRANSVAAL
Lothair
Ermelo
Amersfoort
Wakkerstroom
Newcastle
ORANGE FREE STATE
NATAL
Ladysmith
Estcourt
Mooi River
Pietermaritzburg
LESOTHO
Himeville
Durban
Kokstad
TRANSKEI
Umtata
Butterworth
East London
¼° squares in which Wattled Cranes occurred
Wattled Crane breeding areas
Highland areas (above 1900m a.s.l.)
100 km

Fig. 1.

fluctuate greatly during the period 1978-1982. On average, the population comprised 44.8 adults, 3.0 immatures and 3.3 juveniles (*Table 1*), and the proportion of adults:immatures averaged 94:6 (range 100:0 - 86:14). The proportion of nonjuveniles:juveniles was similar, 94:6 (range 100:0 - 87:13).

Two classes of adults were identified: residents and floaters. Residents were those birds, almost invariably occurring in pairs, which were permanently present at breeding sites, while floaters occurred singly, in pairs, or in small flocks (the maximum recorded together was 20). They often associated with flocks of other crane species, and often wandered far from areas of potential breeding habitat. In the Steenkampsberg the number of floaters in the population averaged 10%, ranging between 0-28%. In Natal the proportion of floaters was higher with 24% of the birds counted in the 1982 aerial census being in this category. The proportion of residents to floaters is influenced by waterlevels in sponges and hence by rainfall conditions: in wet years a lower incidence of floaters is to be expected than in drought years when some of the breeding sponges dry out and residents at these are forced to other feeding sites and, in effect, become floaters. Apart from drought, other factors such as disturbance or the degradation of breeding sites (damming, drainage, etc.) can temporarily or permanently displace residents and demote them to floater status. Thus although the presence of floaters in the population indicates a saturated breeding habitat

Table 1. Census results of the Wattled Crane population in the Steenkampsberg.

Date	Adults Total	Adults Pairs	Adults Floaters	Immatures	Juveniles
1978, Aug	46	19	8	0	3
1979, Jan	50	24	2	4	6
May	37	16	5	6	0
Sept	47	17	12	4	1
Dec	45	19	7	3	2
1980, Mar	46	17	12	2	4
June	44	22	0	2	4
Nov	49	24	1	5	6
1981, Mar	43	21	1	7	3
June	44	22	0	3	3
Sept	53	19	15	1	4
Dec	45	21	3	3	7
1982, Apr	49				
Aug	39	19	1	1	4
Dec	36	17	2	2	2
1983, Mar	43	18	7	2	1
n	16	15	15	15	15
mean	44.8	19.7	5.1	3.0	3.3
S.D.	4.6	2.6	4.9	1.9	2.0

Table 2. Census results of Wattled Cranes at breeding sites elsewhere in the Transvaal.

	1981		1982		1983
	July	Oct	Jan	Nov	Feb
Single bird	.	.	1	2	1
Pair, not breeding	4	6	2	2	5
Pair, with eggs	1	1	.	.	.
Pair, with young	1	4	.	1	.
Three birds	1	1	6	1	1
Number of occupied sites	7	12	9	6	7
Number of pairs	7	12	8	4	6
Number of birds (excluding juveniles)	15	25	23	11	14

Table 3. Results of Wattled Crane census in Natal in May-July 1982.

District	Pairs, With Nests	Pairs, Not Nesting	Floaters	Total Birds
Ntabamhlope	4	0		8
Estcourt	3	0		6
Kamberg	4	0		8
Nottingham Road	6	10		32
Howick	6	2		16
Impendhle	2	4		12
Sani Pass	1	2		6
Pevensey	2	0		4
Himeville	5	4		18
Underberg	5	3		16
Weston	1	0		2
Albert Falls	3	2		10
Mt. Alida	2	0		4
Glengarry	0	1		2
Swartberg	2	3		10
Franklin	3	0		6
Fort Mistake	1	0		2
All districts	50	31	52	214

with a surplus of birds available to fill vacancies in the breeding populations when they arise, it may also indicate a deterioration in the availability of breeding habitat in which drought or some other factor has forced normally resident birds to abandon breeding sites.

Total Population Size

During the period 1978-1982 no synchronized counts of Wattled Cranes were made and the best estimate of the size of the South African population may be obtained by pooling (1) the Steenkampsberg counts (*Table 1*), (2) counts from the rest of the Transvaal (*Table 2*) and (3) counts from Natal made during May-July 1982 (*Table 3*).

In the Steenkampsberg the number of Wattled Cranes present did not fluctuate greatly over 4½ years (C.V. =10%) and most of the fluctuation could be attributed to the number of

Table 4. Wattled Crane breeding records for the Transvaal and Natal, showing months in which egg laying was recorded.

Province	Year	J	F	M	A	M	J	J	A	S	O	N	D	n
Transvaal,	1978	.	1	.	3	.	.	5	2	1	1	3	3	19
	1979	.	.	.	.	3	.	.	3	1	.	3	4	14
	1980	.	1	2	.	1	2	1	1	1	2	.	3	14
	1981	.	.	1	3	.	8	.	3	4	2	1	1	23
	1982	.	.	2	1	1	2	.	1	.	2	1	1	11
	Total	.	2	5	7	5	12	6	10	7	7	8	12	81
Natal,	pre-1973[1]	2	2	1	3	2	5	1	3	3	1	2	5	30
	1980/1	.	.	.	3	7	4	6	3	6	6	3	.	38
	1982	.	.	.	2	9	19	12	7	3	2	2	.	56
	Total	2	2	1	8	18	28	19	13	12	9	7	5	124

[1] Pre-1973 information from Dean, 1971; Walkinshaw, 1973.

Table 5. The size of Wattled Crane egg clutches recorded in the Transvaal and Natal during the period 1978-82.

Province	One-Egg	Two-Egg	n	% One-Egg
Transvaal	31	7	38	81.6
Natal	43	27	70	61.4
Total	74	34	108	69

floaters counted. Elsewhere in the Transvaal counts were made less frequently and these were mainly checks of the potential and actual breeding sites known; thus the number of floaters in this region was underrepresented. In Natal all known breeding sites were checked during seven aerial surveys made between 21 May and 13 July 1982. Combining these results (*Tables 1, 2* and *3*), the best estimate of the *breeding* population in South Africa during the first half of 1982 was 110 pairs (Natal 81, Transvaal 29).

The number of floaters present is more speculative: in Natal a total of 52 was counted (with 35 counted on a single flight) while in the Steenkampsberg there were, on average, five floaters present, but up to 15 have been recorded. It seems very unlikely that the number of floaters occurring elsewhere (Orange Free State, Transvaal, Transkei) could exceed 30 birds, and the best estimates of the *total* Wattled Crane population is thus 277-307 birds, or about 300 birds.

Reproduction

Breeding season. The timing of egg laying of 205 Wattled Crane clutches in South Africa is shown in *Table 4*. In the Transvaal (mainly Steenkampsberg data) Wattled Cranes bred at any time of the year but showed a lower incidence of laying during January to May than during June to December. In the Steenkampsberg pairs exhibited no synchrony in their breeding cycles: even pairs occupying the same sponge could be at a six month variance with each other. On average, successful pairs laid on a cycle of about 14 months (i.e. from the laying of one clutch to the next, assuming the first was successful); relaying occurred sooner if a clutch failed. In Natal the average interval between relaying after the loss of a first clutch was 3 months (range 1-6 months, n=13). There is a disparity in the laying seasons in Natal between the pre-1973 and the 1980-1982 data (*Table 4*): the earlier sample shows that laying occurred evenly throughout the year whereas the 1980-1982 sample indicates a well-defined breeding season with a midwinter peak. The period 1980-1982 was one of lower than average rainfall and the marked seasonal laying peak may indirectly be related to this.

Clutch size and hatchability. One hundred and eight clutches were examined during 1978-1982, 70 in Natal and 38 in the Transvaal. On average, 69% of these were c/1 (*Table 5*), with a higher incidence of c/1 clutches found in the Transvaal (82%) than in Natal (61%). Two-egg clutches never produced more than one chick (in 11 cases in Natal and two cases in the Transvaal). Typically the second egg was laid 2-3 days after the first and the incubation commenced with the laying of the second egg. In one of seven clutches the second laid egg was addled and in six clutches it was fertile; in five of these cases the second egg was abandoned as soon as the first hatched chick was strong enough to leave the nest, even if the second egg was on the point of hatching. One second laid egg was experimentally removed and substituted for an addled egg in the nest of a neighbouring pair and it hatched and produced a chick. Addled eggs were recorded in seven out of 70 eggs (10%) in Natal.

Breeding success. Two measures of breeding success were made: the number of young raised per pair per annum and the success rate of clutches laid. The Steenkampsberg data provide reliable information for assessing the first (y/pr-yr) but not the second whereas the Natal data measure clutch success.

In the Steenkampsberg pairs were recorded on a total of 25 potential breeding sites for part or all of the period 1978-1982, and breeding definitely occurred on 23 of these. (Breeding may have been attempted at the other sites as well but because of the three month interval between census visits it could have gone undetected). In 94 pair-years 39 (with a maximum of 44) young were reared to flying age which gives the productivity as 0.41 (with a possible maximum of 0.47) y/pr-yr. The 94 pair-years is the sum of all the months in which each pair at each breeding site was under surveillance and it includes a few pairs which were never recorded even attempting to breed in 4½ years whereas other pairs were recorded laying as many as nine clutches and raising up to five young in the same period. In a previous review of this population (Tarboton, 1984) by the end of 1980 24 young had been reared in 37 pair-years (0.61 y/pr-yr) and the present much-reduced figure of 0.41 is a consequence of greatly reduced breeding success during the last two years and may be attributed partly to drought conditions.

The success rate of 80 clutches laid in the Steenkampsberg was 0.49 (39 young reared from 80 clutches with the outcome of another five unknown). However, this is probably an inflated estimate of clutch success as clutches which were laid but failed to hatch are underrepresented because of the interval between census visits. During 1980-1982 in Natal 27 out of 49 clutches hatched (0.49 hatched/clutch laid). One-egg and two-egg clutches showed no difference in hatching success. Of the 22 clutches which failed, grass fires accounted for the loss of one, hail for one, flooding for one and addled eggs for one. Fifteen clutches disappeared without trace. Fifteen out of 32 broods of young survived to flying age (0.47 young/clutch hatched). Known causes of chick mortality included grass fires (5) and killed by hail (2). Nine young disappeared without trace. The clutch success rate of the Natal sample is thus 0.23 young/clutch (0.49 x 0.47) and is considerably lower than that found in the Steenkampsberg.

A CONSERVATION STRATEGY

Brooke (In press) has suggested that the Wattled Crane "could easily become extinct as a South African breeding species before 2000 AD," that is, within the next 17 years. We agree that, unless urgent conservation action is taken, Brooke's pessimism is justified. The conservation of the Wattled Crane in South Africa is faced with a number of compounding factors: firstly, its present breeding range falls wholly within the Grassland biome, a region which has undergone and is continuing to undergo massive changes as a result of intensive agricultural practice, mining exploitation, afforestation, damming for water storage, industrialization and urbanization (Mentis & Huntley, 1982). Secondly, its breeding sites are thinly scattered over a wide area; thirdly virtually all of these (105-110) are on privately owned farmland and finally since most of the sites are on sponges in catchment areas they are especially vulnerable to damming projects. For these and other reasons it is most unlikely that a nature reserve or national park sufficiently large to encompass a viable Wattled Crane population will ever be created in the Grassland biome. In formulating a strategy for conserving the Wattled Crane in South Africa it thus needs to be recognized that their fate is effectively in the hands of private landowners, and more specifically, it depends primarily on the actions of fewer than 100 farmers on whose properties they breed.

A Wattled Crane Steering Group was recently formed on which are represented the conservation authorities of the Natal and Transvaal Provincial Administrations, the Endangered Wildlife Trust, the Southern African Ornithological Society and the Coordinator of Nature Conservation Research of the Council for Scientific and Industrial Research. This group has prepared a blueprint for the Wattled Crane's survival which has as its goal the maintenance of a population of about 300 Wattled Cranes in areas of natural habitat in South Africa (i.e. the maintenance of the existing population in its existing range). It recognizes that success hinges on correctly interpreting the needs of the cranes, on involving each landowner in the conservation of the breeding birds on his property, on extension work to maintain landowner interest, on the provision of compensation to landowners to curb development that may have a negative impact on the cranes, on the possible wardening of key sites and on enhanced law enforcement. More specifically, its objectives are as follows:

(1) To identify all existing and potential Wattled Crane breeding sites; to monitor these quarterly; to assess each landowner's attitudes towards the cranes; to assess planned or possible land use changes that may threaten each site

(2) to establish one or more refuges to provide protection for nucleus breeding populations in the event of population crashes in unprotected areas

(3) to set up means whereby breeding sites can be preserved (e.g. pay compensation to landowners prevented from developing sponges or establishing a 'rent-a-vlei scheme).

(4) to enhance public awareness of the rarity of the Wattled Crane and the factors contributing towards this: aim this firstly at specific farmers whose attitudes have a direct bearing on the welfare of the cranes and secondly at the general public, using media such as television, radio, farmer magazines, posters and calendars.

(5) to extend research to the structure, dynamic and movements of nonbreeding crane flocks, the characteristics of sponges used and not used by Wattled Cranes for breeding and resource and habitat use by breeding pairs.

(6) to consider implementing special management techniques (captive breeding, reintroductions, cross-fostering eggs, etc.)

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CHAPTER V

EDITORS' INTRODUCTION: NORTH AMERICAN CRANES

The Whooping Crane (*Grus americana*), an international symbol of threatened wildlife, has made an encouraging recovery. From only 14 birds in 1941, the relict flock migrating between Wood Buffalo National Park, Canada, and Aransas National Wildlife Refuge, USA, has increased to approximately 105 in 1986. The recovery can be attributed to stringent habitat protection, shielding nesting birds from disturbance, hunter education, scientific manipulation, and providence.

Since 1966, a captive flock of Whoopers has been established at the Patuxent Wildlife Research Center in Laurel, Maryland. The successful captive management program there includes inducing each pair to produce several clutches each year by removing eggs as they are laid. This accelerated productivity has not only boosted the Patuxent flock to over 40 birds, but has helped to start a new flock of wild Whoopers in the USA's Rocky Mountains by substituting Whooping Crane eggs into the nests of Sandhill Cranes.

Although Sandhill Cranes number in the hundreds of thousands, two of the six subspecies, the Cuban Sandhill (*G.c. nesiotes*), and the Mississippi Sandhill (*G.c. pulla*), are rare. Even the vast arctic population of Lesser Sandhills (*G.c. canadensis*), and Canadian Sandhills (*G.c. rowani*), may be threatened by the continuing attrition of their spring staging area along the Platte River in Nebraska. Sandhill Cranes remain the most thoroughly studied of any crane species, and in several instances are serving as experimental subjects for testing techniques that may help endangered species.

Under the leadership of Dr. James Lewis (United States Fish and Wildlife Service), North American crane researchers meet every three years to present reports that are subsequently published together as a volume. These include:

1975 Proceedings of the International Crane Workshop, J.C. Lewis, editor. Oklahoma State University Publishing and Printing, Stillwater (1976).

1978 Proceedings of the 1978 Crane Workshop, J.C. Lewis, editor. Colorado State University Printing Service, Fort Collins (1979).

1981 Proceedings of the 1981 Crane Workshop, J.C. Lewis, editor. National Audubon Society, Tavernier, Florida (1982).

1985 Proceedings of the 1985 Crane Workshop, J.C. Lewis, editor. (in press).

MANAGEMENT AND RESEARCH OF WHOOPING CRANES, 1965-1982

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A summary of key events in Whooping Crane (*Grus americana*) studies dating back to 1922 has been provided. The Northwest Territories-Texas Whooping Crane population has slowly increased from 44 wild birds in 1965 to the present 71 birds. Major management efforts involving the removal of surplus eggs from nests in Wood Buffalo National Park and placement in Idaho foster parent Sandhill Crane *(G. canadensis)* nests have not resulted in nest abandonment. Survival of young cranes on the northern breeding range appears to have been augmented by the removal of eggs. Due in part, to the inaccessible nature of the nesting area, aerial surveys are used almost exculsively. Egg removal and colour banding of juvenile cranes are carried out by the simultaneous use of fixed wing aircraft and helicopter. Techniques used in studies of Whooping Cranes may have application for work with other endangered crane species, e.g. Siberian Crane (*Bugeranus leucogeranus*).

STATUS

The Whooping Crane (*Grus americana*) is currently classified as an endangered species in North America. Under existing Canadian statute, an endangered species is defined as: "Any indigenous species of fauna or flora whose existence in Canada is threatened with immediate extinction through all or a significant portion of its range, owing to the action of man." Legal protection for the Whooping Crane was initially secured under the Migratory Bird Convention which was signed jointly by Great Britain (on behalf of Canada) and the United States in 1916. Since that time, additional provisions for federal protection have been enacted in both Canada (Canada Wildlife Act) and the United States (Endangered Species Act). In Canada, the Canadian Wildlife Service (CWS) administers the Migratory Bird Convention Act for the Federal Government.

DISTRIBUTION

The Whooping Crane's breeding range in North America at the time of European settlement appears to have extended from central Illinois and northern Iowa through the south central Canadian prairies, northwest into the parkland region as far as Edmonton, Alberta (Allen 1952). Although historical numbers remain uncertain, it is clear that the Whooping Crane suffered its principal decline in population during the late 19th and early 20th centuries. Migratory Whooping Cranes disappeared as breeding birds in the United

States by about 1890, and the last nest in southern Canada was found in 1922 in the grassland-parkland transition zone near Muddy Lake, Saskatchewan.

By the mid 1930s, only two small populations remained in existence. One was restricted to a small area in southwestern Louisiana and was nonmigratory. Numbering only 13 birds by 1939 (the last year that reproduction was recorded), this population was decimated by a severe storm in 1940 and declined thereafter until the last individual was taken into captivity in 1948. The other breeding population was migratory and occupied winter range along the Gulf coast of Texas. The Aransas National Wildlife Refuge (ANWR) was established in 1937 to provide habitat and protection for the Whooping Cranes and other migratory birds that regularly inhabit the area during the winter months. The breeding range for this population was finally discovered in 1954 near Fort Smith in the northern part of Wood Buffalo National Park (WBNP, established in 1922), Northwest Territories, Canada. Whether this breeding locale was always disjunct or was the northern extent of the original breeding range remains unknown. The Wood Buffalo-Aransas population, as the extant flock is commonly referred to, reached its lowest level (15-birds) in 1941. The population currently numbers 71, although breeding pairs have numbered less than 20 annually to date. Wood Buffalo National Park still contains the only breeding range in North America at the present time. The nesting habitat has been described by Allen (1956), Novakowski (1966), and Kuyt (1981a).

BREEDING CHRONOLOGY AND MONITORING ACTIVITIES

Northward migration of Whooping Cranes from ANWR begins during the last week in March, with the older, experienced breeders and family groups leaving first. Birds begin to arrive on the breeding range 15-28 days later, near the end of April. Nesting may begin by about 26 April and laying is usually complete by 15 May.

Major nesting areas are along Klewi and Sass Rivers (up to 10 nests along Klewi, up to 8 along Sass) with minor nesting areas along Nyarling River (1 or 2 nests) and single nests along Little Buffalo River and Lobstick Creek (Kuyt, 1981a). There is evidence of minor expansion of the breeding range in the latter three areas. Several breeding pairs in the Sass area have been lost, presumably because of old age, but we also have gained some in Sass and Klewi. Several known age (colour banded) birds' first hatching of eggs occurred at four years. Two pairs (each pair consisted of a 3 year old bird and a bird of unknown age) produced 2 eggs each in the banded birds' third year, but the four eggs failed to hatch.

Breeding pair surveys in light fixed wing aircraft start in late April, depending on phenology. We concentrate our search in the vicinity of previous years' nest sites. Sites when plotted on maps assume a "clumped" appearance, suggesting repeat nesting each year by the same pair in the same area. I refer to these areas as 'Composite Nesting Areas' (CNA) - a superimposition of breeding territories over a number of years. We have data for 16 consecutive nests in several CNA. Mean size is 7.5km^2, but more than 70 percent of all CNA measure less than 5km^2 (i.e., 2 sq miles) (Kuyt 1981a).

Locations of birds on nests are plotted on air photos of scale 1:11,811 and clutch size determined by a low pass over the nest, which usually causes the bird to rise. Laying dates are recorded and nest sites photographed. When the full clutch of 2 eggs has been completed, birds are left alone and no further low passes made.

Nonbreeding birds arrive on the summer range about a week later than the breeding pairs. If water conditions are satisfactory, many of them occupy marshy terrain between the Sass and Klewi rivers. Some birds, not quite a year old, accompany their parents to the nest area used the previous year, but these birds eventually spend the summer on the periphery of the breeding territory or nearby.

EGG REMOVALS FOR CAPTIVE PROPAGATION AND CROSS-FOSTERING

As a result of work carried out by dedicated conservationists such as Robert Porter Allen, Fred Bard and others, much was learned about Whooping Cranes in the early days, but the main prize, the location of the nesting area, eluded them. After the fortunate discovery of the cranes' breeding area in 1954, the CWS began carrying out brief surveys over the Sass River area to monitor the cranes (Novakowski 1966).

By the end of 1965, the Whooping Crane population had only increased to 44 birds — an annual increase of 1.2 birds since 1941. Concerned with the slow rate of increase and the continued low population level despite protection and conventional management practices, the CWS and U.S. Fish and Wildlife Service (USFWS) agreed on a plan to remove eggs from the wild in order to establish a captive flock at the Patuxent Wildlife Research Center in Laurel, Maryland, USA, for propagation purposes. The principal objective of the propagation program was to produce stock for bolstering the wild population. This effort represented the first attempt to actively manage the cranes in order to increase their numbers.

The management scheme hinged upon Novakowski's (1966) observation that, although many pairs regularly lay two eggs annually, few of them are accompanied by two young on the Aransas Refuge. Egg removal experiments were subsequently tested on Sandhill Cranes (*G. canadensis*) by the USFWS and indicated that when single eggs were removed from two-egg clutches, nest desertion was negligible and productivity was unaffected (Erickson 1976). Beginning in 1967, CWS personnel removed one egg from each wild Whooping Crane nest containing two eggs (incidence 90.3%). Single egg clutches (8.4%) were not disturbed, and two eggs were removed from three-egg clutches (1.3%). These percentages are based on observations of 237 Whooping Crane clutches between 1966 and 1982.

Methods of locating breeding pairs and removal of eggs have been described by Kuyt (1968, 1976). Briefly, the methods consist of aerial surveys in a light aircraft to locate breeding pairs and determine laying dates and clutch size. Surveys are carried out between about 26 April and 15 May. On or about 28 May, when eggs are about 24 days into incubation (incubation is 29-30 days), the surplus eggs are removed by the project leader operating from a helicopter that lands near each nest. An assistant in a light fixed wing aircraft monitors the behaviour of the parent birds and sometimes assists in the location of nests.

Two trips are made to collect the eggs, and the removal of eggs from nests is carried out in one day. Eggs are kept overnight in Fort Smith in an electric incubator, and shipped to Patuxent the following day. Transport occurred twice by means of commercial aircraft, but in all other cases by small executive jet of the Canadian Armed Forces. Collections were made from 1967-1969, in 1971, 1974 and 1982, and 52 eggs were shipped.

Difficulties in rearing and breeding Whooping Cranes at the Patuxent station in earlier years have largely been overcome, and Whooper eggs laid by captives are now becoming available for transplant purposes (Derrickson & Carpenter 1982). However, the slow progress encountered initially resulted in a number of alternative proposals aimed at bolstering the wild population. The most promising of these has been the cross-fostering program designed by Drewien & Bizeau (1978) of the Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho. In this program, Whooping Crane eggs from WBNP (and, since 1976, from Patuxent) are placed in the nests of wild Greater Sandhill Cranes (*G.c. tabida*) at Grays Lake National Wildlife Refuge in southeastern Idaho. The foster parent Sandhill Cranes hatch the Whooping Crane eggs and raise the young as their own (Drewien & Kuyt 1979).

The techniques for removal of eggs from nests in WBNP prior to transfer to Idaho are identical to those described previously. Transporation of eggs from Fort Smith to Idaho has been carried out by small commercial jet. Eggs are normally in the nests of Sandhill

Cranes one day after their removal from the whooper nests in WBNP. Collections were made each year from 1975-1982, and 116 eggs have been transported to Idaho to date.

MONITORING PRODUCTION AND COLOUR BANDING

After eggs are removed from nests in WBNP for transfer to Patuxent or Grays Lake, we monitor all nests by means of high flying, fixed wing aircraft and record evidence of hatching. Movements of family groups are noted and dates of losses of young are recorded. In most instances, the causes of early chick mortality remain unknown. However, several large chicks are known to have been killed by wolves (*Canis lupus*) (Kuyt 1981b).

Each year since 1977 (from August 7-12) surviving young have been captured and colour banded before thay are capable of flight. Birds are caught by a two man catching team on the ground as well as a coordinator and pilot in a helicopter. Additionally, a fixed wing aircraft (also directed by CWS personnel) flies overhead to monitor the behaviour of the adults and young, and to assist in spotting the family groups which are often difficult to locate from the low flying helicopter. Procedures used in catching and banding, and details concerning the standard metal and plastic colour leg bands have been previously described (Kuyt 1978, 1979a, 1979b). Although we have experienced some losses of bands, we have not found any adverse effects of the actual banding on the birds themselves.

In both 1980 and 1981, blood samples were taken from young Whooping Cranes at the time of their capture for banding. These blood samples were used by researchers at the University of Calgary (Biederman, et al. 1982) to determine the sex of the individual chicks. Although this work was discontinued in 1982 due to the absence of the principal researcher, we hope to continue this work in future years.

DISCUSSION

The removal of Whooping Crane eggs from almost 170 nests in WBNP near the end of the incubation period has not resulted in any nest abandonment or egg loss. Between 1966 and 1982, the average annual number of young fledged has been six, and the WBNP population has slowly increased from 43 birds in 1966 (when management was accelerated) to about 71 birds today — a net increase of almost two birds per year. Egg removals have not only been carried out without adverse effects on the productivity of the wild population, but may have actually enhanced chick survival and consequent recruitment of subadult birds into the breeding segment of the population. During egg collecting years (when only about half of the eggs remain in nests) the survival of chicks has been 6.6 per year and the net increment in the population has been 3.4 birds per year. This compares favourably with years since 1939 when eggs were not collected. During those years, survival of young was only 4.5 chicks per year and the net increment in the population was only 0.84 birds per year. It should futher be pointed out that the figures for collecting years presented above do not include the survival of "bonus" birds added to the Patuxent flock or to the cross-fostered population in Idaho.

Because Whooping Cranes have not been individually marked until recently, many aspects of their biology and life history remain unknown. The current colour banding program was initiated to gather a variety of information, such as: the age of nonbreeders, the age of pairing and first breeding, the average age of first successful nesting, the fidelity of individuals to nesting territories and mates, the movements of family groups and other banded birds, the age and identity of birds colonizing new areas and the frequency of remating. Although this banding program has now been underway for only 5 years, we have already gained a great deal of information that would otherwise be unavailable. Furthermore, colour banding has enabled detailed studies dealing with the behaviour of nonbreeders on the wintering grounds to be completed (Bishop & Blankinship 1982). The tremendous increase in our knowledge facilitated by colour banding will undoubtedly enhance Whooping Crane conservation and management efforts in the future.

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WHOOPING CRANE MIGRATION STUDIES 1981-82

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ABSTRACT

A radio tracking study of Whooping Cranes (*Grus americana*) migrating between their breeding range in Wood Buffalo National Park and their winter range at the Aransas National Wildlife Refuge was initiated in 1981 by the United States Fish and Wildlife Service and the Canadian Wildlife Service. Objectives of this investigation were to document the migration pathway, determine the nature of the habitat used by migrating Whooping Cranes, determine methods of migration flight, and document potential migration hazards and mortality factors. Prefledged Whooping Cranes were captured and marked with coloured leg bands to which small radio transmitters were attached. During migration, birds were followed and monitored from aircraft. Fall migration consisted of three distinct portions: a relatively quick flight in the second half of September from the nesting area to Saskatchewan agricultural areas; a leisurely 2-3 week "staging" period in Saskatchewan; and a rapid migration of about a week during which cranes crossed the United States. Enroute, the birds used undisturbed agricultural areas and wetlands for feeding and roosting. Migration flight during optimum conditions was by means of upwards spiralling followed by rapid downward gliding. Major hazards encountered by the cranes included transmission lines, military exercise areas and aircraft traffic.

INTRODUCTION

The migration ecology of the Whooping Crane (*Grus americana*) has remained poorly known despite several coordinated migration monitoring programmes in the United States and Canada. In order to complement and expand existing information, the Whooping Crane Recovery Plan (USFWS 1980) suggested that radio telemetry studies during migration be initiated. Following preliminary studies of migrating Sandhill Cranes (*G. canadensis*) (Melvin & Temple 1980) and a single, cross-fostered juvenile Whooping Crane (Drewien & Bizeau 1981), the United States Fish and Wildlife Service (USFWS) and the Canadian Wildlife Service (CWS) implemented a cooperative radio-tracking study of migrating Whooping Cranes. The joint programme was started in 1981, with the USFWS providing most of the funding, manpower, and equipment. Objectives of the study were:

1. To determine the migration pathway for one or two Whooping Crane families during migration from the breeding range in Wood Buffalo National Park (WBNP) to the winter range at the Aransas National Wildlife Refuge (ANWR).
2. To identify habitat utilization during stopovers by migrating whoopers and to determine essential or critical habitat.
3. To document method of flight, altitudes and other facets of behaviour of migrating birds.
4. To identify potential and actual hazards during migration.

METHODS

Radio transmitters were mounted by small bolts on the regularly used 80mm colour leg bands (Kuyt 1978, 1979a, 1979b). Radios measure about 80mm by 40mm, with an antenna of about 250mm. The antenna is encased in heat-shrunk plastic, and is covered with a coil spring at its base. Three nickel cadmium batteries and solar panels provide power for the transmitter. The batteries, solar panels and transmitter components are protectively encased in dental epoxy. Total weight of radio, band and antenna is from 63-79 grams. Radios operate in the 164-165 MHz range. The distances from which radio signals could be picked up by our receivers varied with relative location of radio and receiver. Maximum reception distances were: ground-to-ground 4-6km, air-to-ground 45km, and air-to-air 125km. Additional information about radios and receiving equipment can be found in Drewien & Bizeau (1981).

The radio colour band packages were placed above the tibiotarsus of juvenile whoopers on the Klewi, Nyarling, and Little Buffalo River portions of the breeding range in early August 1981 and 1982. Three birds were equipped in this manner in 1981 and six in 1982. Two of the latter were subsequently killed by a wolf before the cranes fledged.

RESULTS

Young whoopers fledge at about 70 days (15-20 August). From time of banding (9-15 August) until 7 September, daily movements of family groups (two parents and radio equipped juvenile) did not exceed 5km. The only time a young bird was observed to fly before migration was on 7 September 1981, when a family group made a low flight of about 1.2km. We observed no evidence of migratory restlessness in 1981, and little, if any, in 1982. In 1981 and 1982, J.P. Goossen, CWS biologist, and I were able to radio track six family groups and two yearlings during parts of these birds' migration. *Figure 1* shows the flight track of two families followed in 1981 and *Table 1* provides chronological details of a family's flight in 1982.

Case Histories

Klewi River family

Apparently without making any preliminary flights, the Klewi River family started its 1981 migration in midmorning on 17 September. By late afternoon, radio signals picked up by the tracking aircraft indicated the birds had landed. Unfortunately, due to equipment malfunction and dense smoke from huge forest fires, we were unable to locate the cranes until 20 September. They were then observed feeding among sedges (*Carex* spp.) surrounding a 1.5km long, unnamed lake about 400km southeast of the nesting area. The birds remained there until 23 September, apparently because of smoke and unfavourable weather.

Weather conditions on 23 September featured north winds and good visibility, and the Klewi family departed about 0930. The birds were radio tracked to a military exercise range in east central Alberta where the tracking aircraft could not follow. On 25 September we located the family group in a small wetland in the northern portion of the Saskatchewan grain belt, 425km southeast of the North Steepbank area stopover site (Fig. 1). The birds remained here until the middle of October.

On 11 October the Klewi chick flew into a power line and injured its back. It was rescued and transferred to the University of Saskatchewan, Saskatoon for veterinary care, but never regained the use of its legs and died about a week later.

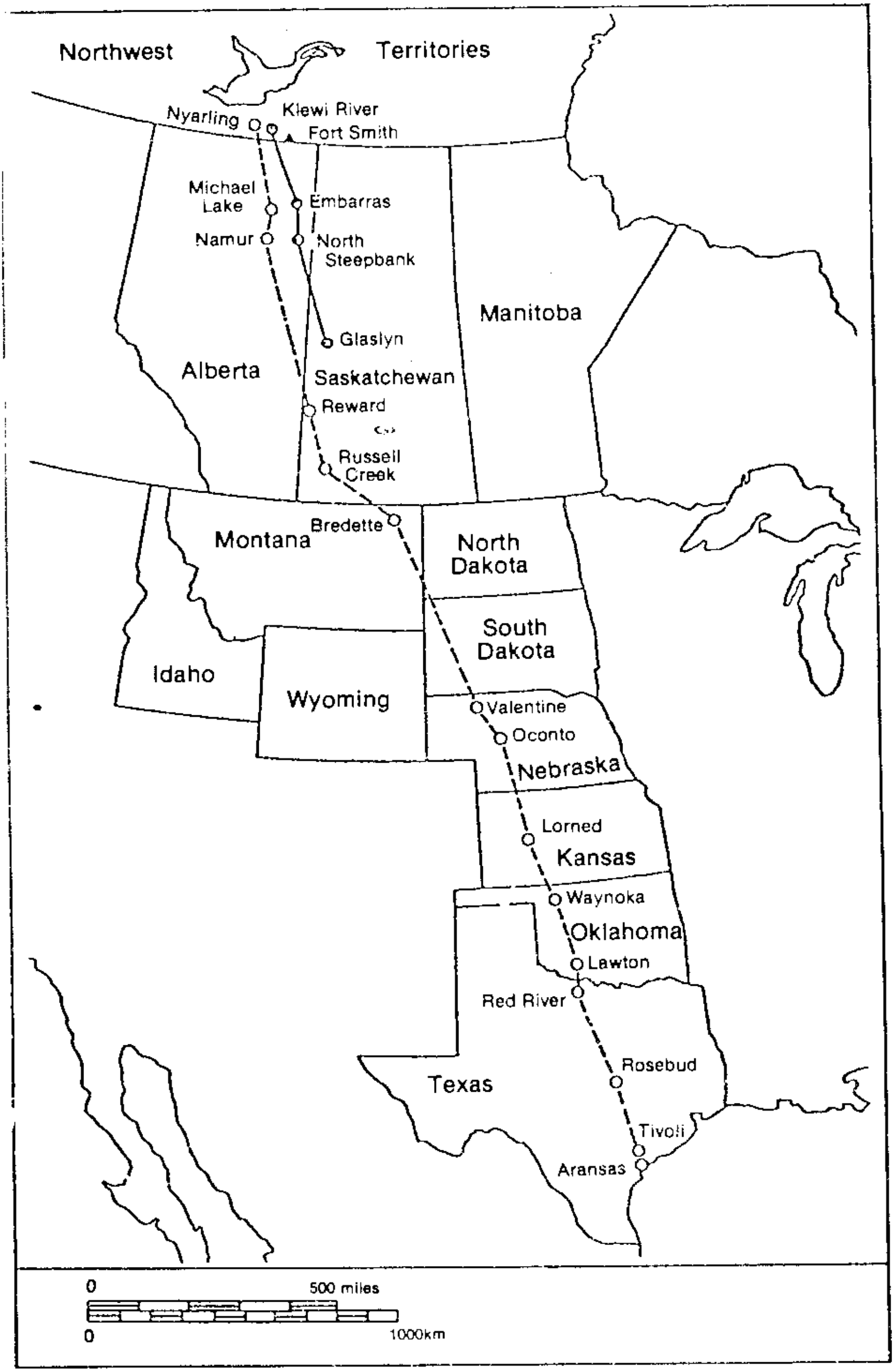

Fig. 1. Flight tracks of two migrating whooping crane families, 1981.

Table 1. Details of migration flight, family 10/82, 1982.

Landing Site No.	Date	Departure area	Time	Arrival area	Time	Distance
1.*	8 Oct.	Nest territory	Est. 1000 hrs	80km SW of Ft. Smith, NWT	Est. 1200-1300	80km
2.*	9 Oct.	80km SW of Ft. Smith, NWT (Site 1)	Est. 0930 hrs	109km N of Ft. McMurray	1547 hrs	203km
3.*	10 Oct.	109km N of Ft. McMurray	0955 hrs	26km NE of Primrose Lake	1725 hrs	299km
4.*	11 Oct.	Site 3	Est. 1000 hrs	Stony Lake, Sask.	Est. 1500 hrs	204km
5.	14 Oct.	Site 4	Est. 1100-1115	26km N of Davidson, Sask.	1705 hrs	275km
6.	15 Oct.	Site 5	1415 hrs	40km NE N. Battleford, Sask.	1830 hrs	212km
7.	16 Oct.	Site 6	0800 hrs	72km NE Lloydminster, Sask.	1126 hrs	113km
8.	17 Oct.	Site 7	Est. 1300 hrs	29km NE of Lloydminster	Est. 1430 hrs	48km
9.	18 Oct.	Site 8	Est. 1100 hrs	13km NW of N. Battleford	Est. 1300 hrs	97km
10.	27 Oct.	Site 9	1016 hrs	Radville, Sask.	Est. 1700 hrs	451km
11.	28 Oct.	Site 10	Est. 0730 hrs	16km NW Beulah, N.D.	Est. 1130 hrs	306km
12.	29 Oct.	Site 11	1030 hrs	10km NW Eureka, S.D.	Est. 1600 hrs	257km
13.	30 Oct.	Site 12	0945 hrs	23km SW Eureka, S.D.	1155 hrs	26km
14.	31 Oct.	Site 13	1120 hrs	Swan Lake, 6km NW of Hoven, S.D.	1245 hrs	39km
15.	1 Nov.	Site 14	1033 hrs	19km S of Alnsworth, Neb.	1716 hrs	325km
16.	2 Nov.	Site 15	Est. 0640 hrs	Ft. Cobb Reservoir, Okla.	Est 1730 hrs	818km
17.	3 Nov.	Site 16	0900 hrs	26km NE Refugio, Texas	Est. 1845 hrs	772km
18.	4 Nov.	Site 17	0902 hrs	Dunham Bay, ANWR	1013 hrs	48km

*Goossen, pers. comm.

Nyarling River family

The Nyarling family (two adults and radio equipped juvenile) had been radio tracked following a 4 October departure from the breeding range to Reward Saskatchewan (*Fig 1*) by Goossen. This family also appeared to have been delayed by unfavourable flying weather enroute. I followed the Nyarling family from Saskatchewan to its 3 November landing on the winter territory at ANWR (*Fig. 1*).

Little Buffalo River family

This family was last seen on its home range on 15 October 1981 (B. Bourque, pers. comm.) and most likely the birds left before a 17 October weather disturbance. The three cranes were not radio-tracked but arrived at ANWR on 8 or 9 November.

Nyarling River yearling

This bird, in company of three other Whooping Cranes, left the summer range on 15 September 1982 and was radio tracked by Kuyt to southern Saskatchewan. Contact with the birds was lost when they continued flying after dark. The radio equipped yearling was found dead under a powerline near Waco, Texas on 16 October 1982.

Little Buffalo River yearling

This bird was not a primary subject for radio tracking but its signal was detected on several occasions when other birds were being monitored. The yearling departed its summer range on or about 15 September. I located the bird on 16 September as it roosted with another bird 112km northeast of North Battleford. Its signal was again picked up on 18 September as the bird apparently continued its migration south into the northern part of the USA. Here the bird apparently remained for some time, because on 12 October I located the whooper in the company of 20 Sandhill Cranes near Williston, North Dakota. The yearling was later detected (by radio signals) by Goossen who also sighted the bird briefly in Texas. The whooper arrived at ANWR, apparently alone, on 3 November, 1982.

Lobstick family 10/82

The Lobstick family left the breeding range on 8 October and was radio tracked by Goossen to Saskatchewan, then by Kuyt to ANWR where the birds landed on 4 November, 1982 (Table 1).

Family 6/82

Family 6/82 was detected on 21 October in Saskatchewan. The family became a primary tracking subject after the loss of the Nyarling River yearling. Family 6/82 left WBNP about 19 October and was followed from Saskatchewan by Goossen to a 3 November landing at ANWR.

Family 2/82

This family was monitored only incidentally. The birds were first encountered on 21 October in the Saskatoon area. They left WBNP about 19 October and landed at ANWR on 3 November, 1982.

Family 1/82

This family was detected in the Garson Lake area, 95km southeast of Fort McMurray, Alberta on 14 October (I. Ross, pers. comm.). It is likely the birds left WBNP the previous day. They were encountered several times in Saskatchewan, incidentally to our tracking of primary birds. The three cranes landed at ANWR on 11 or 12 November.

MIGRATION

Migration sequence

Fall migration can be divided into three parts. The first consists of a relatively rapid and direct flight from the breeding range to the Saskatchewan grain belt, a distance of over 1000km. The cranes can make this flight in two or three days if weather conditions are favourable. The second part of migration consists of a period of resting and feeding in the agricultural areas of Saskatchewan. This "staging" period extends from arrival from the breeding range until departure for the winter range, and may last as long as 24 days. During this time the cranes utilize small wetlands (for roosting, drinking, feeding and loafing) as well as barley and wheat stubble fields (primarily for feeding). This period is likely of great importance to whoopers, as they probably gain the lipid reserves necessary for making the remainder of the journey. We have seen as many as 30 whoopers, many of them colour banded individuals, in groups of from 2-10 birds in the south central portion of Saskatchewan. Many of the birds were first reported to us by farmers on whose land the birds were feeding and resting. The third, and final, part of the migration consists of a relatively rapid series of flights from the staging area to the winter range. Departure from the staging areas is probably stimulated by the advent of colder weather (including snow and northerly winds) coupled with physiological readiness (as indicated by shortened periods of feeding).

Although the analysis of the accumulated radio tracking data is not yet complete, several observations made by air and ground crews are of general application and are summarized briefly below.

Daily migration routine during flight days

Mean times of departure and arrival during days that Whooping Cranes migrated were 0925 and 1644 hrs. During that time interval, the cranes flew for an average of 6 hr 28 min daily. Daily flights covered between 21 and 750km, the latter consisting of a 9 hr 38 min nonstop flight from northeast Montana across the Dakotas to northwest Nebraska (Fig. 1). Feeding and drinking periods averaged 51 min daily.

The Nyarling family travelled the 3957km migration route at a mean ground speed of 45.5km/hr. Although the birds normally flew between 250 and 450m above ground, several times they reached heights of 2000m. Nearly one-half of the time we were able to maintain visual contact with the migrating cranes from our aircraft.

During periods of suboptimal flying conditions, the cranes would use low altitude flapping flight. Flapping flight was observed primarily in the early morning and late afternoon, and was probably associated with low thermal activity. During warmer weather, cranes would alternate between spiralling and gliding. The maximum 1981 flight (9.5 hrs, 750km) was an example of this more rapid flight method.

Interactions with other birds during flight

We observed frequent encounters of radio tracked Whooping Cranes with Sandhill Cranes. Movements of both species appeared to be influenced largely by weather condtions. On a number of occasions migrating sandhills and whoopers merged into one flock. Our impression was that the sandhills usually sought out the whoopers rather than the reverse. On several occasions, especially in the central USA during times of high density sandhill crane movements, sandhills and whoopers formed mixed flocks for up to several hours. A Sandhill Crane family (adults and chick) flew with a whooper family for a similar period, gliding and spiralling in unison with the whoopers.

In 1981, the Nyarling family was joined by a pair of whoopers as the birds flew over Duck Lake, Nebraska. The pair, apparently resting on the lake edge, flew up and joined the migrating family. The five birds flew as a loose formation several times, usually becoming separated during spiralling, whereupon the pair eventually caught up again. After about 30 min, however, the pair separated from the family and disappeared.

A much more lasting association began in 1982 on Swan Lake, South Dakota. On 31 October the radio tracked family landed on Swan Lake and was soon joined by a hitherto unseen pair of whoopers that had been roosting with a flock of Lesser Snow Geese (*Chen caerulescens*). The five whoopers continued migration on 1 November and remained together until late on 3 November when visual contact with the birds was lost in southern Texas, due to darkness. The following morning the family was located 45km northwest of its winter territory at ANWR. It is likely that the pair continued to its destination at ANWR the previous night.

Five Black Vultures (*Coragyps atratus*) were observed on 2 November 1981 as they soared in the same area as the Nyarling family in southern Texas. It is likely that the vultures were utilizing the same thermals as the whoopers.

Daily feeding routine during staging period (G. Vandel, pers. comm.)

Birds generally flew from their overnight wetland roost to nearby agricultural fields to feed about 30 min before sunrise. Upland feeding periods, which last about 2 hrs, were alternated throughout the day with periods of relative inactivity at the wetland site. Although principal behaviour in wetland habitat included resting, preening and sleeping, some foraging was noted. The final upland foraging period was usually terminated about 30 min after sunset, when the cranes would return to their wetland roost for the night.

Daily feeding routine during migration period

Before migration was initiated each day, Whooping Cranes usually made a short flight and fed in a field for a period of up to 2 hrs. Many times the birds were observed to return to the wetland roost to drink before beginning the day's prolonged migration flight. At the completion of the day's journey, the cranes typically fed before roosting, but almost always the birds would initially land in a wetland site rather than in a stubble field or pasture. Only brief periods were spent feeding after migration started each morning.

Character of feeding sites (G. Vandel, pers. comm.)

Most feeding areas had good horizontal visibility and were less then 3km from the roost site. Barley and wheat stubble fields were preferred. Grasslands were used, but seemed to be of lesser importance. Ground crews, directed to crane feeding areas by aircrews, were able to determine that food consisted primarily of small grain (waste barley, wheat, milo), seeded wheat, and sometimes waste corn in mulched fields. The cranes fed on insects in pasture land, and on frogs, fish, crayfish and rodents in marsh habitat.

Character of roost sites (G. Vandel, pers. comm.)

Most of the documented roost sites consisted of small stock ponds or other wetlands. Usually these roosts had good horizontal visibility and were less then 3km from cultivated fields. Wetlands used for roosting typically had minimal shoreline vegetation, bare pond bottoms, and gentle surrounding slopes. Cranes roosted in wetlands only several hundred metres from farm building on a few occasions, but most sites were located 1km or more from human dwellings and disturbances.

Migration hazards

During major portions of the Whooping Cranes' migration, the birds were observed flying at altitudes well above existing power transmission lines. At the beginning and end of daily flights (or at times of rest stops) lowered altitude would bring the cranes in close proximity to overhead wires. In 1982 we twice observed Whooping Cranes flying under power lines. On several other occasions we witnessed cranes continuing low altitude flight after sunset, when the birds were apparently searching for a suitable roost. Such flights obviously increase the risk of collision with power lines. Two radio equipped birds, a juvenile in Saskatchewan in 1981 and a yearling in Texas in 1982, were killed as a result of collisions with power lines.

Radio tracked Whooping Cranes flew through a number of military exercise areas in

Canada and the USA. The low flying military jets, artillery exercises, and helicopter traffic observed by tracking crews are all potential hazards for migrating Whooping Cranes. When previously alerted by tracking crews, military personnel cooperated with our migration study by diverting military aircraft and other activities from the migration corridor.

On several occasions radio tracked whoopers passed through areas of high density aircraft traffic (e.g. Dallas-Fort Worth). In some instances, our pilots were able to advise local air traffic controllers who subsequently diverted air traffic, thereby decreasing the potential for collisions with the migrating cranes.

CONCLUSION

Radio telemetry is a valuable method for gaining information on migration ecology that could not be obtained reliably or consistently using any other technique. Accurate information on the location of the Whooping Crane's migration corridor, flight speeds, flight method and altitude, habitat use, and behaviour of the birds aloft and on the ground can be collected because the observers are able to maintain close contact with the same birds throughout the migration. In two seasons of radio-tracking we have learned more about Whooping Crane migration ecology than through all of the previous migration monitoring programmes. For example, we were able to document the extent and importance of the Canadian prairie staging area through information gathering on colourmarked and unidentified Whooping Cranes encountered en route during the course of the radio-tracking. Of additional importance, this information was gathered by trained personnel rather than (or in addition to) that obtained by untrained observers.

Because of data collected on habitat use (chiefly by ground crews) it may be feasible to identify habitat types and to designate particular areas essential for migrating Whooping Cranes.

During fall tracking in 1981 and 1982 we were able to document two instances of mortality of whooping cranes and the cause (collision with power lines). This mortality is relatively high, considering the small size of the population (70-73 birds) and the current recruitment of 3-6 fledged young per year. Our radio tracking studies clearly indicate that additional work needs to be initiated immediately to document and, possibly, mitigate the hazards posed by powerlines to migrating whoopers.

Because of the initial success of this technique in Whooping Crane studies and the vast amount of new information obtained, further radio tracking is planned for the fall of 1983 and spring of 1984 by the USFWS and CWS.

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RESEARCH AND MANAGEMENT PROGRAMS FOR WINTERING WHOOPING CRANES

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ABSTRACT

Whooping Cranes (*Grus americana*) reached a low population of 21 birds due to loss of nesting habitat. Present population of 71 (Feb. 1983) is derived from flock numbering 15 in 1941, which nests in Canada and winters in marshes and bays of Texas coast. Major foods are blue crabs and clams. Research began in late 1940 s on behavior, habitat parameters, and food habits. Several management techniques have been tried including people control, refuge establishment, supplemental feeding and burning and grazing of dense cover.

INTRODUCTION

The large size, beautiful appearance, extreme rarity, and long international migration route of the Whooping Crane (*Grus americana*) have caused it to catch the public interest and to become the unofficial symbol of the struggle to save endangered animals in North America.

The Whooping Crane population reached a low of 21 individuals in 1941, 1944, 1952, and 1954. All Whooping Cranes now alive, however, are descended from the "Aransas - Wood Buffalo" flock which numbered only 15 birds in 1941. This population has slowly increased to a peak of 78 birds in the wild in 1980 and the present count in early spring of 1983 is 71 birds. This flock has also produced, with human help, captive and experimental wild populations such as the one used to develop a new flock in association with Sandhill Cranes (*G. canadensis*) in Idaho.

The decline of the Whooping Crane to near extinction is believed to have been primarily a result of loss of nesting habitat. The historic nesting range during the period of North American settlement included large portions of the states of Illinois, Iowa, Minnesota, North Dakota, and southern portions of the Canadian provinces of Manatoba, Saskatchewan and Alberta (Allen, 1952). Most of this area was converted to agriculture with settlement, and wetlands that escaped drainage are now too close to human activities for the whoopers to tolerate.

As the Whooping Crane population dwindled with loss of nesting habitat, other factors became more and more important in speeding the decline. Old records and photographs show that many birds were lost to hunting. Egg collecting was a popular hobby, and as the Whooping Crane became increasingly rare, its eggs were more and more in demand. The same was true of the demand for scientific specimens. Rural electrification programs of the late 1920 s and 1930 s laced the cranes' migration route with powerlines, the collision hazard of which we are only now beginning to realize.

The Whooping Crane is a bird of strong traditions, and we are now dealing with a relic population that probably always nested on the extreme northern fringe of the species breeding range and wintered on the central Texas coast. This "Aransas - Wood Buffalo" population breeds in Wood Buffalo National Park in Canada's Northwest Territories. They migrate some 1140km to spend the winter on the Aransas National Wildlife Refuge and nearby islands on the Texas coast of the Gulf of Mexico, some 60km northeast of the city of Corpus Christi.

The winter habitat consists primarily of some 20,000ha of salt flats and marshes, shallow bays and tidal ponds and sloughs separated from the Gulf of Mexico by long and narrow barrier islands. Vegetation of the marshes is dominated by smooth cordgrass (*Spartina alterniflora*), sea ox-eye (*Borrichia frutescens*), saltwort (*Batis maritima*), glasswort (*Salicornia* sp.) and salt grass (*Distichlis spicata*). Upland grasslands and stands of live oak (*Quercus virginiana*) are also used by the cranes under favorable conditions as when flooded by heavy rains or following fires.

The heart of the Whooping Crane habitat on the Aransas NWR is bisected by the Gulf Intracoastal Waterway, which is used for barge transport of petroleum products and industrial chemicals and for passage of numerous sport and commercial fishing vessels. The danger of a petroleum or chemical spill is ever present.

Approximately 75 percent of the winter habitat has refuge or wildlife management area status under federal or state control. Another 10 percent is operated as wildlife sanctuary by the National Audubon Society and approximately 15 percent is privately owned.

WINTER HABITS

Whooping Cranes, migrating in small flocks, pairs, family groups or as singles, begin to arrive on the Texas coast about 15 October and most are present by late November. Occasional stragglers may arrive in late December. Spring departure occasionally starts in late March but most often begins after 1 April, with the last birds usually gone by 1 May. In 10 of the past 42 years, one to four cranes have remained to summer on the Texas coast. Some of these appeared to be ill or injured, while others seemed in good health (Aransas Refuge files).

The Texas wintering area is apparently a safe location, as only 13 losses of Whooping Cranes have been detected there since 1950 (Aransas Refuge files).

The cranes usually arrive to find the flats and marshes well flooded by high tides and heavy fall rains. Blue crabs (*Callinectes sapidus*) are the major food item at this time. In December and January, these tidal areas drain with lower tide levels and the cranes move into shallow bays and channels to forage on clams of at least six species: *Tagelus plebeius*, *Ensis minor*, *Rangia cuneata*, *Cyrtopleura costata*, *Phacoides pectinata*, and *Macoma constricta*. Blue crabs are also taken while probing the bottom for clams. Other items used as food by Whooping Cranes include: fruit of *Lycium carolinianum*, acorns (*Quercus* spp.), common fiddler crabs (*Uca pugilator*), mud shrimp (*Callianassa jamaicense*), white shrimp (*Penaeus* sp.), eels (species unknown), snakes (*Natrix sipedon clarki*, *Thamnophis souritus proximus*), and crayfish (*Cambarus* spp.). (Blankinship 1976; Olsen 1980).

Mated Whooping Crane pairs establish winter territories that are defended against intrusion by other Whooping Cranes. There is much variation among pairs in the vigor of defense of these territories, with some sharing of area or tolerance of certain birds permitted. These territories range in size from 69ha to 712ha with an average of 176ha (Allen 1952; Blankinship 1976).

RESEARCH PROGRAMS

Surprising little research has been conducted on the Whooping Cranes on the wintering ground. This may result from the extreme rarity of the birds, which precludes many usual research methods and the fact that only recently (1977) have any of the "Aransas -Wood Buffalo" flock been color banded to allow identification of individuals. Researchers are largely relegated to just sitting and watching for long periods of time.

The first real field research was conducted by Robert Porter Allen of the National Audubon Society under the Cooperative Whooping Crane Project with the U.S. Fish and Wildlife Service (then the U.S. Biological Survey). Initial assembly of available information began in 1945. In late 1946, Allen began 39 months of intensive field observations and then additional literature review, which culminated in *The Whooping Crane*, a monograph published by the National Audubon Society in 1952.

Time passed and the Whooping Crane population more than doubled. Human activity in and around the cranes' wintering habitat has greatly increased. Industrial development, oil and gas production, shell dredging, use of agricultural chemicals, and barge and sportboat traffic have all greatly expanded. Better information was needed on the cranes' food habits, on food availability in relation to climate conditions, on spatial requirements and territorial behavior in an expanding population, and on the effects of increasing human activities in and around the cranes' habitat. With more of this information available, better management planning and evaluation would be possible.

A study of potential Whooping Crane food organisms and related physical factors was conducted in 1965 and early 1966 by Bill Van Tries and Gordon Folzenlogen of the U.S. Fish and Wildlife Service.

In November 1970, the National Audubon Society assigned David R. Blankinship to conduct research on behavior and habitat of Whooping Cranes on the Aransas NWR and adjacent islands and peninsulas. This study was designed to update and add to the results of Allen's study, and to continue and expand upon the efforts of Van Tries and Folzenlogen. Much of the work on this project has been conducted on the Aransas NWR under a cooperative agreement with the FWS.

Research activities in this ongoing project include recording physical water data, collecting food-organism availability data by seining and bottom core sampling, and examining fecal samples for food habit information and occurrence of disease organisms. In addition cranes are intensively observed for food habits and other behavioral data, territorial maps are developed from water, ground, and aerial observations, and crane food items are analyzed for possible chemical contamination. Preliminary findings have been published (Blankinship 1976) and more comprehensive reports are planned.

A study of the environmental effects of oyster shell dredging in San Antonio Bay adjacent to the Aransas NWR was conducted by Texas A&M University in 1972 and 1973. Some sampling efforts were coordinated with the Audubon Society project. The general conclusion was that shell dredging did not appear to have marked adverse effects on the Aransas NWR. Long-term effects could be difficult to detect, however, with such shortterm research effort.

The Canadian Wildlife Service in 1977 began to place colored plastic leg bands on almost all young Whooping Cranes produced each year in Canada. Thus, for the first time it is possible to be certain of the identity of individual birds and to follow their activities from year to year. Blankinship's study has been extended to allow long term observation of the marked birds.

The marked birds are yielding data on survival rates, longevity, age at pairing and first breeding, sibling matings, intraflock social relationships, patterns of territory establishment, territorial fidelity, and territorial succession.

Mary Bishop, a Texas A&M University graduate student, conducted a study of subadult Whooping Crane flocking behavior on the Aransas NWR during the 1979-1980 and 1980-1981 winters.

Howard Hunt, also a Texas A&M University graduate student, is presently conducting a study entitled "The Influence of Various Burning and Grazing Treatments on Upland Habitats Use by Whooping and Sandhill Cranes on the Aransas National Wildlife Refuge."

Aerial surveys of the Whooping Crane habitat are conducted weekly by personnel of the

Aransas National Wildlife Refuge and one or two times weekly by Texas Parks and Wildlife Department personnel. These surveys are made from a single engine high-wing type aircraft. Survey flights are made at altitudes of 50-170m. The cranes do not appear unduly disturbed by the aircraft and, at times, do not stop feeding as the plane passes over.

The Aransas flights provide population counts, distribution data, information on banded birds, and also monitor for threats to the birds. The state flights are designed to evaluate the effects of waterfowl hunting on the distribution of the cranes.

All agencies involved in Whooping Crane wintering ground research have been most cooperative in sharing of data and providing assistance when needed.

MANAGEMENT PROGRAMS

It has often been said that wildlife management is really people management. This is certainly true of the Whooping Crane, where the great public interest in the species and the public desire to see the bird could result in great disturbance or abandonment of habitat.

Access to the Whooping Crane habitat on the Aransas National Wildlife Refuge is strictly controlled from the land side. An elaborate observation tower has been provided to allow visitors to view the habitat and often the cranes also.

Access by water is not controlled except by laws prohibiting harassing of the birds. Whooping Cranes are quite tolerant of people in boats. Most visitors view the cranes from commercial tour boats, which provide an excellent opportunity to approach the hirds without disturbance. One of these boats and her captain have been making Whooping Crane trips for 20 years. This particular boat has a capacity of 150 persons and makes 4 or 5 trips per week, often with a full load.

Waterfowl hunting

A buffer zone around the Aransas National Wildlife Refuge is closed to waterfowl hunting, but other areas of whooping crane habitat are hunted. Posters are placed in most hunting blinds located in Whooping Crane use areas warning hunters to watch out for the cranes and giving details and pictures to aid in identification. Only one Whooping Crane is known to have been shot by a hunter on the wintering grounds since the establishment of the refuge in 1937.

The arrival of the cranes is well publicized in the fall, which aids in increasing hunter awareness.

Habitat protection

Two of the most important events in Whooping Crane history were the establishment of the Aransas National Wildlife Refuge in 1937 and the Wood Buffalo National Park in 1922. The significance to Whooping Cranes of the 11 million acre Wood Buffalo National Park was not realized until 1954 when the nesting grounds there were first discovered.

The Aransas National Wildlife Refuge contains 21,862ha and was established to protect Whooping Cranes, waterfowl, and other wildlife of coastal Texas.

Any party wishing to do any development work in coastal waters must obtain a U. S. Army Corps of Engineers permit. Requests for such permits are carefully reviewed by the U. S. Fish and Wildlife Service, National Audubon Society, and the Texas General Land Office. Plans that could be harmful to whooping cranes are denied or required to be modified so as not to be a threat.

Food supply management

During the 1950 s and 1960 s it was believed that Whooping Cranes were short of food during low water periods in midwinter. Subsequent research has shown these low water conditions actually make new feeding areas available where the water had been too deep. The importance of clams in the midwinter diet had not been realized.

Several management techniques were tried to increase the cranes' food supply, but all have now been discontinued. It is possible that some form of supplemental feeding could be needed during an extended period of very cold weather or during a drought period when high salinity levels might cause a shortage of natural food.

Two 100 acre fenced enclosures were developed during 1964-1968 and a variety of root crops and grains were grown. Some Whooping Crane use occurred, but most of the food crops were consumed early by the more numerous Sandhill Cranes and Canada Geese. (Shields & Benham 1969).

Another innovation was construction of a 70 acre impoundment equipped with a high volume pump designed to draw large quantities of saline water and marine life from the shallow bay into the basin. The exit of food items such as crabs was prevented by screens at spillway exits. A problem was if the bay was short of food items for the cranes, they would not be available to be pumped into the impoundment.

Whooping Cranes did respond to large amounts of grain dumped on the flats as did Sandhill Cranes, geese, ducks, turkeys, hogs, etc. This form of supplemental feeding was practiced for at least 10 years until the early 1970 s. It was realized this method created a threat for disease transmission and was discontinued. This method may have application in drawing Whooping Cranes away from a chemical or oil spill. (Forrester, Carpenter & Blankinship 1978).

Burning and grazing

Upland sites on the Aransas National Wildlife Refuge tend to grow rank with grasses and scrub oak when not managed. Whooping Cranes will use these areas at times when cover is reduced by mowing, grazing, or burning. They particularly respond to burned oak scrub where acorns are exposed. Experimental burning and grazing programs are now underway in cooperation with Howard Hunt's research to determine the optimum technique.

It is hoped continued research will produce new ideas for improved Whooping Crane habitat management and avoid ineffective or even dangerous efforts.

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MANAGEMENT OF THE MISSISSIPPI SANDHILL CRANE

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ABSTRACT

The Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR) in Jackson County, Mississippi, begun in 1974, is nearly complete with an area of 6,500ha. The Mississippi sandhill crane (*Grus canadensis pulla*) population is approximately 40, plus 11 or 12 free flying captive raised birds. The objectives of the Recovery Plan (1979) are to save the crane in the wild from extinction by preserving, protecting, and enhancing the crane environment through habitat manipulation and biological management to increase the population to 80 to 100 cranes.

Habitat manipulation for breeding, roosting, and feeding areas includes (1) hand clearing of selected areas, (2) prescribed burning of savannas and pine lands, (3) harvesting and bulldozing of pine timber to create openings and croplands, (4) constructing water control structures and plugging ditches to maintain marshy areas and improve the water economy, and (5) providing crops and supplemental food.

Under the federal Young Adult Conservation Corps program 323ha of overgrown nesting habitat were hand cleared from 1979 through 1982. Prescribed burning was done on 170ha in 1980, and wild fires burned 407ha of refuge lands. In 1981, 395ha were burned purposely and 1328ha were burned in wild fires. Little timber was harvested but 607ha of noncommercial pine plantation were removed by bulldozing, of which 81ha were converted into cropland and pasture. Five watercontrol structures were completed in 1980, but the roads which serve as dams have not yet been raised.

Biological management consists of maintaining a captive breeding flock at the Patuxent Wildlife Research Center, and translocating parent raised cranes into the MSCNWR. In 1981, 9 subadults were released on the refuge after about 6 weeks in an acclimation pen, and in February 1982, 5 others were liberated. The cranes were tracked through radio transmissions and by visual observations.

Of the 1981 released cranes, 6 survive; 2 are "paired" with wild birds. The 1982 translocation failed; 4 died; 1 was recaptured and returned to Patuxent. In October 1982, 7 others were put into the acclimation pen where they remained for 6 weeks before being freed. The translocating program adds more to the population than do the wild pairs. The first released cranes will reach breeding age in the spring of 1983, when we hope they will nest. Nest counts, ground and aerial surveys monitor results of management.

Habitat management exclusively for breeding cranes is quite new, but the tried principles of game management apply. Hunt and Gluesing (1976) attribute the increase of breeding sandhill cranes in Wisconsin to the acquistion and restoration of 145,000ha of wetland by state and federal agencies. The projects originally were to improve breeding and feeding grounds for waterfowl and to provide public hunting, but as conditions improved sandhill cranes began occupying suitable breeding sites. Management of crane habitats in northwestern Wisconsin by the Department of Natural Resources includes (1) water control through levees and control structures, (2) prescribed burning of uplands and wetlands to maintain a mix of brush, prairie, and marshland as breeding and roosting habitats, (3) cultivation of food plots for feeding resident and staging cranes, and (4) sanctuaries within the game management areas to protect the cranes during the hunting season (Crete & Grewe 1982).

Sandhill cranes once nested nearly everywhere in North America north of Mexico where the combination of wetlands (marsh and shallow water), prairie and isolation provided an ideal environment. The cranes were extirpated as human populations grew and the most fertile lands were occupied. Now cranes exist mainly in lands of low economic value, unsuited for cropland agriculture or intensive timber culture, and away from settled areas. Man's works ruined many former crane environments, but improved some. The clearing of pine woodlands for grazing in the Kissimmee River Valley, Florida, expanded the prairies, making the region more habitable for cranes (Walkinshaw 1976).

Most of the Florida sandhill cranes (*G. c. pratensis*) breed on cattle ranches located in the central part of the state. The cranes are generally protected, but no management is practiced. The Loxahatchee National Wildlife Refuge (58,900ha) in southern Florida and the Okefenokee National Wildlife Refuge (150,140ha) in southern Georgia have breeding flocks of cranes. Because of the large size of these refuges only a slight control of water levels is possible. No habitat manipulation is done and no winter foods are provided. The number of cranes wintering in Florida has been increasing since the early 1970's, but no management program for cranes has been implemented. When in private ownership, Paynes Prairie in north central Florida was burned and grazed, providing both breeding and wintering habitats. Now it is a state owned preserve with a change in management emphasis; it is rarely burned or grazed, resulting in a deteriorating environment for cranes and declining populations (Nesbitt 1977).

Lumbering and the burning of the coastal pinelands in Mississippi by Indians and early settlers opened up wet prairies for cranes. The circumstance of infertile, water logged, acid soils and the friendly attitude of the few people living in the area preserved a nucleus of cranes that we are fortunate to have existing today.

Management in Mississippi is based on assumptions that reflect observations and experience. We assume cranes prefer open sites to nest in because among 83 nests 47% were found in open savannas, 36% along swamp edges, 11% in pine plantations, and 6% along pine forest edges (Valentine 1982). The common element was a degree of openness with similar ground cover. Cranes abandoned territories when the site became overgrown with brush and trees. Water, while considered important in nest site selection, was less crucial: 49% of nest sites were dry at the initial visit, 13% only moist, and 38% were wet (Valentine 1982). Feeding, roosting, and resting in spring, summer, and early fall were observed in habitat types similar to those used for nesting. Grains (corn, barley, wheat, milo) are major components of the diets of migrating and wintering cranes, but there are areas in Florida where such grains are scarce and the cranes rely on natural foods. In winter, Mississippi cranes forage in harvested corn fields or in pastures where corn is fed to cattle. We may ask, if southern nonmigratory cranes require grain for their existence? They certainly are attracted to corn, and croplands are used to lure the cranes from private lands to the protection of the refuge. Crop units where cranes congregate are also useful to survey populations and recruitment.

STUDY AREA

The U.S. Fish and Wildlife Service (FWS) began acquiring lands in 1974 for the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR), located in southern Jackson County, Mississippi. Acquisition is nearly complete, with 6500ha toward the projected total of 7000ha (Fig. 1). There is little prospect of managing lands within the historical range outside of the refuge. The MSCNWR has the best and virtually the only remaining breeding range. Of 21 active territories found (1965-1982, inclusive), all but 3 were found on lands that are now part of the refuge. Of the 3 outside the present boundary, only 1 may still be active. There are small bits of breeding habitat left but these are scattered and surrounded by forest or agricultural lands.

Climate

Jackson County has a humid, subtropical climate with an annual average (1940-1960) rainfall of 184cm (range: 92 to 235cm). Half of the yearly rain falls in June through September; droughts and tropical storms are common. Summers are hot and winters alternate between warm and cold weather. Snow is rare, but freezes occur each year.

Topography

The land is low (6 to 9m elevation in the Fontainebleau Unit and 12 to 15m in the Ocean Springs Unit), gently undulating, and poorly drained. Prior to man's intervention, rain, water, slowed by vegetation, flowed across the land surface to small streams connected with larger drainage systems that ended at the Gulf of Mexico. Heavy soils and high water tables inhibited downward percolation, trapping water in swamps (Ben Williams, Bear, and Perigal) or in marshy sumps and wet savannas. With the building of highways, timber access roads, and drainage ditches for timber management and housing developments, the natural flow was disrupted and drainage accelerated.

The northern part of the crane breeding and winter feeding range outside of the refuge is a rolling landscape (elevation 15 to 30m) compared with the flatlands to the south. The few breeding territories in this zone are situated in the open valley sumps that are surrounded by forested hills.

Vegetation

Plant communities in the crane breeding range were described by Valentine & Noble (1970). The density of tree and brush cover in 4 nesting habitat types (open savanna, swamp edge, pine plantation, and pine forest edge) was analyzed by Valentine (1982). The savannas were present when the first white men arrived on the Gulf Coast. Lightning and Indian hunting fires doubtlessly created and maintained the open prairies. In 1699, d'Iberville (Brasseaux 1981) described the land inland from present Ocean Springs as "a very pretty pine woods...several prairies, where I saw many deer; and soft sand everywhere." LePage du Pratz (1774) in 1720 said the fields were "pleasant enough, but less fertile than along the Mississippi." Hilgard (1860) in 1859 gave an excellent description of the vegetation of the savannas he called "glades", "pine meadows", or "meadowland." The long leaf pine were "diminutive" and the glades as "pleasing to the eye; and it is difficult at times to dispel the illusion that it is a park laid off by human hands..." From present Gautier to Ocean Springs he passed almost entirely through the wet pine meadows.

After the Civil War and into the 20th century, the virgin pine forests were logged, stimulating the growth of seaports and towns. Open range grazing of cattle, sheep, and goats and fires kept the pine from regenerating. Open range policy was abolished in the 1950 s, when the timber companies acquired most of the land and began planting pine.

Population

The population estimate centers around 40 plus 11 or 12 free flying captive raised birds. In the past six years we have found ten active territories, but not all had nests every year. In that time two new territories were discovered. Of the ten territories that were active, eight were located on the refuge; all of the active nests found during the past three years were found on the refuge. Of 21 recognized territories since 1965, 11 have been abandoned. The greatest number of nests found in one season in the past six years has been six, exclusive of renesting (range: 2 to 6). Few birds-of-the-year are seen in the fall and mortality appears to equal recruitment.

HABITAT MANAGEMENT

Prior to the establishment of the MSCNWR, threats to the crane environment included timber management, roads and highways, commercial, industrial, and housing developments (Valentine & Noble 1970). Pine was planted on thousands of ha during the

1950s and 1960s. To encourage the growth in wet situations, drainage ditches were dug and pine seedlings were bedded and furrowed. Access roads and firebreaks crisscrossed the previously inaccessible forest and grassland tracts. The pine plantations and natural pine stands were given greater protection by roads and firebreaks. Fire suppression was improved by better surveillance, improved firefighting equipment, and protection by the Mississippi Forestry Commission. As a result, the pine plantations grew into large dense stands that precluded nesting and feeding by cranes. Unplanted drier savannas grew up into brush and pine from natural regeneration. A few thousand ha remained suitable for nesting habitats as scattered wet openings within an area of 50,000ha.

The original Mississippi Sandhill Crane Recovery Plan (Valentine et al. 1976) was approved by the FWS and revised in 1979 (Valentine et al. 1979). The plan outlines habitat management for the MSCNWR: (1) Restore savannas and marshy areas by burning, harvesting pines, and plugging drainage and road ditches, and (2) Increase and improve nesting sites by harvesting timber, hand cutting, retaining tree and shrub buffer zones to separate nesting territories, planting or retaining tree cover along highways, and constructing water control structures.

Hand clearing

Hand clearing consists of chopping pine trees and brush with axes or brush hooks, or cutting with hand-held power saws. This method is used best in potential or active nesting wet site habitats that have become overgrown. Hand clearing can be done with a minimum of ground disturbance, but it is labour intensive and slow. The sites can be cleared with precision following vegetation and elevation contours. The biologist must recognize optimal nesting habitat and direct the crews where to cut, and what to leave as buffer zones between the prospective territories. Without a federal program such as the Young Adult Conservation Corps (YACC), clearing with axes and power saws would be difficult to accomplish. A labour crew in the U.S.A. for jobs such as this may be hard to find. Volunteers of college or high school age might be available, but there is an element of physical danger in using people unskilled in the use of axes and power saws.

The YACC crews cleared 111ha of overgrown nesting habitat in 1980 and 212ha in 1981. It is too early to assess the program but a clearing cut in 1979-1980 in an area that had not been used since 1974 held an active territory in 1981. This pair had probably been driven out by a fire, because they did not return to the cleared area, but went back to their original territory in 1982. Before the refuge was acquired a timbered area that had been clear-cut by a timber company held a nest in 1981 and again in 1982. Prior to the cutting of the timber, the area was totally unsuited for crane nesting.

Commercial harvest

The refuge contains 1200ha of dense pine stands that were planted in open grasslands in the 1950 s. Much of this timber is now harvestable and will be sold and clear cut as part of the grassland restoration program. About 100ha have been commercially cut since the refuge was established.

Bulldozing

The Bicentennial Land Heritage Program (BLHP) provided funds to national parks and wildlife refuges for the construction of facilities and habitat improvement. Under this program 607ha of noncommercial pine timber were bulldozed and later burned to provide feeding habitat. Of the total, 81ha were converted to crop and pasture land.

Roller-Chopper

Another technique used for restoring grassland was the use of a rolling chopping drum pulled behind a crawler tractor. The crawler tractor has a blade that helps push the trees down. The water filled chopping drum has a series of cutting bars that crush down pine trees (up to about 20cm diameter breast height) and cut the trunks and branches into smaller pieces. This method is very effective in opening noncommercial pine plantations with little disturbance of soil and ground cover. About 4ha of pine plantation was rolled and chopped in December 1981. Rainy weather and loss of YACC personnel precluded additional work.

Isolation

Cranes prefer to nest and feed in places secluded by distance or by cover. The distance between nests and human activities has been discussed by various researchers (Taylor 1976, Howard 1977, Valentine 1982, Carlisle 1982). While there are exceptions to the rule, cranes usually nest away from human activity, including vehicular traffic. The roar and rumble of highway traffic never ceases on the MSCNWR, where two major federal highways and six minor highways transect or border the refuge. Forests isolate most breeding areas from visual disturbance from roads and highways, and, where forest clearings were made, strips of pineland were left to buffer noise and movement. Some trees will have to be planted to shield a pasture and savanna from Interstate Highway 10. Borders of brush and pine trees were left between actual and potential hand-cleared nesting sites. The distance between territories was less where small openings were isolated by trees and brush than in large open savannas where one pair dominated the entire opening (Valentine 1982).

Prescribed Burning

Configurations of terrain, poorly drained soils and fires promoted and maintained the savannas near the Gulf Coast. Well into the 20th century, the white settlers used the practice of burning to produce green winter grazing for livestock. The end of open range, the timber industry, and better fire suppression limited burning after the 1950 s. Fire protection, pine plantations, and natural regeneration of pine made thousands of ha unsuitable as crane habitat (Valentine and Noble 1970).

Burning of forests has been an accepted technique in the southeastern U.S. to control forest diseases and brush and to lessen the severity of wild fires. Game managers use fire to maintain open areas and encourage the growth of certain food plants for quail, turkey and deer. Controlled burning is one of the most economical methods for removing vegetation for a prescribed purpose. However, burning is imprecise and the effect on vegetation depends on many factors (undergrowth, water and moisture conditions, plant species, season, time of day, periodicity, wind speed, direction, etc.). Fire plans must provide for equipment and man power needs, safety, fire breaks, logistics and trained personnel.

At present, burning is permitted but regulated in Mississippi. Smoke and fire control on the MSCMWR is imperative because of the proximity of urban developments and federal highways (Interstate Highway 10 and U.S. Highway 90), state, and county roads. Federal refuge regulations require that persons involved in controlled burning and fire fighting must be trained at accredited workshops.

The main objective of burning on the MSCNWR is to maintain or create openings by killing small pine and setting back the growth of brushy species such as gallberry (*Ilex glabra*), wax myrtle (*Myrica cerifera*), black gum (*Nyssa sylvatica*), and yaupon (*Ilex vomitoria*). Small slash pine (*Pinus elliottii*) (up to 6mm diameter breast height) are killed easily in hot fires but baldcypress (*Taxodium ascendens*) resprouts from the base. No research has been done to measure the actual effect of burning, but observations indicate that brush species produce many stems from basal parts of the plant, but the profile is low for several years. Fires stimulate a vigorous growth of grasses for several years, and then the plants revert to a more stunted growth form. To kill or inhibit the growth of shrubs, fires must be frequent, at least once every three years. Recently burned areas are attractive to cranes as feeding sites. The open ground exposes roots, insects, crayfish, and other food items. Burning has been used in conjunction with bulldozing of the pine plantations to hasten the decay of the pine debris and the control of brush.

Fires have been traditional in the South as an expression of grievance against landowners or merely for mischief and pleasure by "fire bugs." Local anger, because of the controversial interchange on Interstate Highway 10 and the establishment of the MSCNWR (Valentine & Noble 1976) sparked an increase in the number of arson fires during the 1970 s and 1980 s. While not a part of the refuge's management plan, these wild fires serve the same purpose if they're not damaging in other aspects.

Prescribed burning began on the MSCNWR in 1977, when 202ha were burned. No controlled burns were made again on the refuge until 1980 when 170ha were burned. In 1980, 15 wild fires occured on the refuge affecting 407ha. A spring drought in 1981 resulted in the worst fire season in 20 years. Over 2000ha were burned in the area including 607ha on the refuge during 19-20 March. During the year, 10 wild fires, mainly from arson, burned a total of 1328ha on the MSCNWR; an additional 395ha were planned burns.

Burning should be done after the breeding and chick rearing season (between 1 October and 1 February) to avoid killing juvenile cranes and other ground nesting birds. Potential breeding localities should be thoroughly examined to determine whether or not the cranes are nesting or have recently nested. Savannas that contain active nests should not be burned, because the fires destroy the nests and the dried vegetation required for the building of nests. If a burn is necessary because of brush and tree encroachment, the active nesting area can be isolated from the fire by the use of fire breaks.

Burning an active territory may result in the cranes permanently abandoning the site. A territory used in 1965 and 1966 was not used again after a wild fire burned the savanna in the winter of 1966-1967. Another territory that has been used intermittantly since 1966, and continuously each year since 1974, was abandoned for one season after a fire burned through the swamp nesting site in March 1981. This pair is believed to have moved their nesting activities 2.6km away to another savanna but returned to their original territory in 1982.

Summer feeding habitat

Summer feeding habitat is managed to provide an abundance of open dry and wet grasslands. The opening of wetter sites for nesting will provide aquatic forms such as crayfish, frogs, tadpoles, and fish. Documented evidence relating to food habits is scarce but dewberries and blackberries (*Rubus* spp.) and other fruit seeds have been found in crane droppings. Invertebrates, such as earthworms, adult and larval insects, spiders, and crayfish are present and doubtless eaten.

Though there are no quantitative data available, I believe soil dwelling invertebrates are scarce. During the bulldozing of pine plantation and the preparing of crop lands, windrows of vegetation, roots, and topsoil were left to decompose. After these stood for a year or so, earthworms became locally abundant and cranes were seen probing for them. Some crop units should be dedicated for the production of earthworms and insects by adding lime, fertilizers, and large amounts of organic matter. Reinecke & Krapu (1979) in their food habits studies implied that invertebrates, particularly earthworms, may play an important role in supplementing protein intake. In the present natural regime of periodic sustained droughts, the water courses and roadside ditches dry up completely, and aquatic animal life dies. When the water control structures are in place and road dams are functioning, it may be beneficial to restock the ponded areas with native fish, frogs, and crayfish to provide another source of protein.

Grazing

Cattle and cranes associate amicably on the wintering grounds of southern U.S. and on the feeding grounds of Mississippi. Cattle grazing is found on virtually all of the known feeding fields in Jackson County. There are three characteristics of cranes and cattle associations: (1) a stock pond, (2) an almost overgrazed low turf, and (3) supplemental feeding of corn. Cranes probe in the pastures for invertebrates, turn over or probe the cattle dung searching for insects and undigested corn kernels, and glean corn scattered for cattle. Two former landowners have permits to graze horses on pastures acquired as part of the refuge. An enlarged cattle grazing programme is being considered.

Winter feeding

During the 1950 s and 1960 s corn was grown on the small farms within the feeding range north of the refuge. Cranes fed extensively in the corn fields after the corn had been harvested. Very little corn is now being planted. In the 1970 s and into the 1980 s many ha of pine were cleared and planted to Soybeans (*Glycine max*). Cranes are rarely seen in soybean fields.

Cropland has been cleared and some attempts have been made to grow corn, sorghum, and Japanese Millet (*Echinochloa crus-galli*) on the refuge but with little success because of infertile and acid soil. With better cultivation and the addition of lime and fertilizers, crops can be raised, but at this time the scattering of corn kernels is sufficient. Production of Chufa (*Cyperus esculentus*) will be tried when planting stock is available. These plants produce underground nutlets that are eagerly sought by cranes. Chufa may be an ideal food for Siberian (*Bugeranus leucogeranus*) and White-naped cranes (*Grus vipio*) and other aquatic feeding cranes.

WATER MANAGEMENT

Water is important to the cranes for drinking, bathing, and maintaining the required nesting, feeding, and roosting habitats. Of 77 Mississippi nests examined, 38 were in dry sites, 10 in moist, and 29 in wet (Valentine 1981). These data indicate that the Mississippi crane accomodates to dryer nesting conditions than most other subspecies, with the exception of the Cuban and some populations of the lesser Sandhill (Walkinshaw 1953, 1965). The marshy condition of most nesting sites is primarily determined by water saturated soils. The roosting area in the Pascagoula River marsh consists of ponds and freshwater marsh, but the cranes also roost in the savannas in the breeding habitats.

Slowing runoff of rainfall is an important initial step in habitat management. Roads and fire breaks constructed by agencies and former owners have ditches that rapidly shunt water into the natural drainage systems. Ditches were also dug to drain pine plantations. The roadside ditches should be plugged in many places to impede drainage, but this will create hydrological problems and makes road maintenance difficult. One solution has been to limit the number of maintained roads on the refuge.

Five water control structures were constructed in 1980 through the BLHP. These structures are basically concrete boxes fitted with culverts and stop-logs to regulate water levels. The controls were placed in existing roads that crossed natural drains and streams. The road elevations will be raised to form dams to impede water flow, but not to create large impoundments.

If additional marshy areas are required for an expanding crane population, low level levees can be constructed across minor drainage systems to hold a depth of up to 25mm of water on small areas a few ha in size. The levees would be grass covered, and low natural spillways would allow runoff of surplus water. If the levees are washed out, they can be repaired with minimum effort.

Some years after the large pines were logged (early 1900 s) the stumps were pulled out of the ground and processed for the concentrated resins. The numerous depressions left in the ground serve as wells for drinking water and as reservoirs for aquatic plants and animals. The deeper roadside ditches have a useful purpose as sources of water for the cranes during periods of drought, but on rare occasions even these go dry.

A study is in progress to determine the feasibility of using percolate water from a waste water treatment facility that will be located on the north border of the MSCNWR. The water will be treated in a lagoon system, then sprinkled on a hayfield where the grass will be cut, baled, and removed. Surplus water will percolate through 1.5m of soil, collect in drain tiles, and surface at a lower elevation. From there the water will flow through strips of pine forest and natural grassland into leveed wetland. The irrigated hayfield (100ha) will be suitable as a winter feeding area and the leveed wetland units should revert to nesting habitat. At present the area is a pine plantation about 30 years of age.

PREDATOR CONTROL

Predation on eggs by birds and mammals is a major factor in nest success in Oregon (Littlefield & Ryder 1968), Michigan (Walkinshaw 1965), and to a lesser extent in Idaho (Drewien 1973). Egg predation by crows is negligible on the MSCNWR, occasioned only through human disturbance (Valentine 1981). Feral or stray dogs wander through the refuge and were responsible for the death of at least one released captive raised crane, but no other mammalian predation has been documented. The removal of a sanitary fill dump in the vicinity of the refuge that was attractive to crows may reduce the summer crow population. Garbage and road kills along highways attract potential bird and mammalian predators. The arguments for and against killing predators will not be discussed, but I believe control of predators of endangered species may be justified. In a well balanced ecosystem where crane populations are secure there should be little need for it. All habitat manipulations should be designed to provide ideal conditions for the cranes without attracting or encouraging predators.

BIOLOGICAL MANAGEMENT

Introductions of captive-raised cranes

The pros and cons of breeding and releasing of captive-raised birds have been debated for many years. Konrad (1976) discussed the history of captive crane breeding and various methods for implementing reintroductions. Recently, a number of releases have been made with varying degrees of success (Nesbitt & Williams 1973, Nesbitt 1979, Drewien et al. 1981, Zwank & Derrickson 1982).

The removal of 1 egg from 2-egg clutches for captive propagation has been done with Whooping Cranes, and Greater, Florida, and Mississippi Sandhill Cranes without an adverse effect on the wild populations, and has been the principal method of assembling breeding flocks in captivity. Egg collections have been made yearly in Mississippi from 1965 (except 1978, 1979, 1980) to 1982. There are now 19 Mississippi Sandhill Cranes, including 5 breeding pairs, at PWRC and 2 pairs at the National Zoological Park facility, at Front Royal, Virginia. The goal has been to assemble a flock of 10 breeding pairs with the greatest possible heterozygosity, by trying to collect eggs from all of the pairs extant in the wild. Progeny from the captive flock are raised at the PWRC for release into the MSCNWR.

A total of 21 subadults have been freed in 3 releases (1981, 1982, 1982) on MSCNWR. The captive, parent reared subadults were shipped from the PWRC, banded, brailed, and equipped with radio transmitters, and confined to an acclimation pen for about six weeks and then were allowed to fly out. Their movements and activities were monitored by radio and sight observations. Methods and results of the first release were detailed by Zwank & Derrickson (1982).

The first release of 9 parent reared young occurred in February and March 1981. For about 6 months the 9 remained together as a flock and then split into a flock of 6, a "pair", and a single. One of the "pair", found dead in October 1981, had suffered a blow to the head; another, found in November, was too badly decomposed to determine the cause of death. At present, 6 are surviving. Two appear to be "paired" with wild cranes, another associates with a flock of wild cranes, and 3 remain in their own flock.

The second release of 5 young-of-the-year proceeded with similar methods in February 1982. These subadults had remained with their parents almost until they left PWRC. They did not remain as a flock in the acclimation pen as had the 9 of the previous release, and when they were given their freedom they separated into singles or twos. The first mortality was on 19 April 1982, when one was found dead on Interstate Highway 10, which bisects the refuge. Two may have been killed by dogs on the refuge; another was found dead in poor condition with lesions on the tongue. The fifth was captured wandering around the parking lot of a shopping center and was shipped back to PWRC to enter the breeding flock.

In December 1982, the third release took place when 7 were allowed their freedom after 6 weeks in the acclimation enclosure. Six birds have survived at the writing of this paper, 10 months after the release.

Some observations may be derived from these experiences: (1) subadults penned together early in life and remaining together in an acclimation pen for 6 weeks stayed together when released; (2) parent reared *pulla* subadults survived longer than the handreared *pratensis* in Florida (Nesbitt 1979); (3) larger groups remaining together survived longer than small groups that separated into entities of ones and twos; (4) flocks of wild nonbreeders are not seen in Mississippi, indicating a very small recruitment and that life for single birds-of-the-year may be very hazardous; (5) an acclimation period in an enclosure containing natural wetland and supplemental food may be required for survival of the cranes to be released; (6) the released birds used the enclosure for some months as a focal point before gradually extending their range; (7) at least 3 of the cranes have a bond with wild cranes; (8) 3 of the original 9 maintain a flock, with 2 behaving as a "pair"; and (9) early fall releases increases the opportunity for association and interaction with native cranes at the feeding grounds.

Egg Switching

The Recovery Plan (Valentine et al. 1979) suggested switching PWRC produced eggs with wild eggs as a method of increasing numbers and heterozygosity. Recently we have been using the egg flotation method (Derrickson & Carpenter pers. comm.) in the field to determine the stage of development of the chick within the egg. With this information it is possible to substitute viable wild eggs or eggs from captive cranes into nests that hold eggs being incubated but no longer alive. We have found that cranes will often continue to incubate long after the normal period of 30 days (Valentine 1982). In 1982, 3 eggs nearly ready to hatch at PWRC were substituted for nonliving eggs in 3 wild nests. One hatched, but apparently died early. Another hatched at the predicted time, but on the following day the chick was found dead at the edge of the nest. The third egg was crushed by the sitting crane after being incubated 24 days at PWRC and 6 days in the wild. After examining the egg, we found that the chick had died after about 27 days of incubation.

The question arises whether fertile eggs at PWRC should be hatched and raised for future releases as live subadults or used in the wild as substitutes for infertile eggs. Experience indicates that survival from chick to fledgling in the wild may be less than 1 in 5. However, egg switching gives the wild birds, particularly young cranes, the possible experience of raising a chick.

In the original Recovery Plan (Valentine et al. 1976) we suggested that placing Florida or Georgia Crane (*pratensis*) eggs in *pulla* nests could increase heterozygosity. A number of objections were received after the Plan was reviewed. In the revision (Valentine et al. 1979) the proposed addition of another genetic strain was deferred.

The translocation of captive reared cranes into the wild is still in the experimental stage and most conclusions are subjective and tentative. Aspects of the programme have been successful enough to elicit optimism, but the ultimate test is whether the released cranes will survive to produce young.

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COMPARISON OF RELEASE METHODS FOR PARENT REARED MISSISSIPPI SANDHILL CRANES

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ABSTRACT

A captive breeding program of Mississippi Sandhill Cranes (*Grus canadensis pulla*) is being conducted at Patuxent Wildlife Research Center (PWRC), Maryland, to make available parent reared cranes for release at the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR), Missisippi, to augment the endangered wild population. Birds to be released were preconditioned to a diet of corn and pelletized food at PWRC. After shipment to MSCNWR, the brailed cranes were held in an acclimation pen for habitat and native food conditioning. Cranes were transported to MSCNWR and released into the acclimation pen in January 1981 and January-February 1982. Prerelease conditioning of the cranes at PWRC differed between the 2 releases. The 9 cranes (8 juveniles and 1 subadult) released in 1981 were taken from parents and placed in a common pen approximately 5 months prior to shipment to MSCNWR. The 1982 released cranes (5 juveniles) were allowed to remain with their parents until shipment. Conditioning and release procedures were similar for both years after the birds arrived at MSCNWR. All cranes were marked with color coded leg bands and radio transmitters before they were released into the wild. Additionally, the 1982 released cranes were marked with number coded neck collars. Brails were removed from both groups after 2-6 weeks of conditioning, after which cranes could leave the release pen. Maximum dispersal from the release site for any of the 1981 cranes was 14.3km, occurring 20 months after the release. Dispersal in excess of 2.7km was not observed until 10 months postrelease. Maximum dispersal for any of the 1982 cranes was 8.9km, occurring 1 month after release. All of the 1981 cranes survived the first 6 months of release, and 6 survived through February 1983. Only 1 1982 released crane survived more than 2 months after release. The single survivor was recaptured in an emaciated condition 5 months after release. Two years postrelease, 3 of the 1981 cranes have formed permanent associations with wild cranes, including 2 that have apparently formed pair bonds with wild birds. No permanent associations between wild and 1982 released cranes were observed.

The Mississippi Sandhill Crane (*Grus canadensis pulla*), described as a new subspecies by Aldrich (1972), is a nonmigratory population confined to southern Jackson County, Mississippi. The colony is presently the only representative west of Florida of a breeding population once found from Louisiana to Georgia and into peninsular Florida (Walkinshaw 1949, Valentine & Noble 1970). This crane was officially listed as an endangered species on 4 June 1973. The Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR) was established in Jackson County in 1975 and the Recovery Plan (Valentine et al. 1976) for the crane was approved by the U.S. Fish and Wildlife Service (USFWS) in September 1976.

The revised Recovery Plan (Valentine et al. 1979) suggested bolstering the depressed native crane population by the release of parent reared Mississippi Sandhill Cranes into the wild. During 1965-1982, Mississippi Sandhill Crane eggs were collected nearly each year from nests in the wild (Valentine 1981). In the early years of the program, eggs were incubated in the backyard aviary of John Lynch (USFWS Biologist) at Lafayette, Louisiana, and later at the propagation station at Monte Vista National Wildlife Refuge, Colorado (Valentine 1981). A captive propagation center was established at the Patuxent Wildlife Research Center (PWRC), Laurel, Maryland, where a breeding flock was established (Carpenter 1977, Derrickson & Carpenter 1981). A program for providing parent reared cranes for release into the wild was begun at PWRC in 1975, and the first group of young cranes from this program was made available for release in 1981.

STUDY AREA

The study was conducted within the 41,000ha area in southern Jackson County, Mississippi, comprising the entire range of the Mississippi Sandhill Crane (Valentine 1982). This area, previously described by Valentine & Noble (1970), contains the 6800ha MSCNWR and presently supports a population of 40-50 wild Mississippi Sandhill Cranes (Valentine 1981). Three habitat types used extensively by wild Mississippi Sandhill Cranes are savannas, farmlands, and refuge crop units. Savannas are open grasslands characterized by wiregrass (*Aristida* spp.), toothache grass (*Ctenium aromaticum*), and pitcher plants (*Sarracenia* spp.); with scattered stands of longleaf pine (*Pinus palustris*), slash pine (*P. elliottii*), and baldcypress (*Taxodium distichum*). Many areas of natural savanna have been converted to slash pine plantations since the 1950 s, but refuge personnel have restored some of these savannas by bulldozing and cutting planted pines. Savannas are maintained by burning. Cranes use grazed pastures for feeding areas in the winter months, eating corn (*Zea mays*) given to cattle as a diet supplement and probing in cow feces, presumably for undigested corn and other food items. Harvested corn and soybean (*Glycine max*) fields are also used by the cranes as winter feeding areas, as are refuge crop units planted in corn, ryegrass (*Lolium* spp.), sorghum (*Sorghum* spp.), or left fallow.

The release site, located on the 2800ha Gautier Unit of the MSCNWR, was described in detail by Zwank & Derrickson (1982). The release site has become increasingly utilized by wild cranes as a winter feeding area. Refuge personnel annually plant winter ryegrass and scatter shelled corn on the crop areas to feed released cranes and attract wild cranes. Restored savannas are located adjacent to the release site and serve as midday loafing and feeding areas for cranes during the winter. In 1982, a pair of wild cranes nested 1.4km west of the release pen and fed regularly at the release site during the summer.

METHODS

Parent reared Mississippi Sandhill Cranes were made available for release through the captive propagation program at PWRC. Vinyl wing brails were used to render the young cranes flightless at approximately 70 days of age. Cranes selected for release in 1981 were taken from parents at approximately 120 days of age (October 1980) and placed together in a 0.5ha flight pen after wing brails were removed. In the flight pens, cranes were supplied a pelleted food in self feeders which was later supplemented by corn and cracked wheat. Prior to shipment, the cranes were weaned onto a diet of corn and pellets to prepare them for foods provided at the release site. The cranes were examined before shipment. Cranes selected for release in spring 1982 remained with their natural or foster parents until shipment. All other preconditioning was similar to that received by the cranes selected for release in 1981.

Cranes were shipped by air freight to Mobile, Alabama and trucked to the MSCNWR release site. Before being released into the 2.4ha acclimation pen, each 1981 crane was equipped with a leg band mounted radio transmitter (Telemetry Systems, Inc., P.O. Box 187, Mequon, Wisconsin, and Telonics, Inc., 1300 West Univ., Mesa, Arizona) previously used in another study. For further description of these transmitters, see Drewien et al. (1982). Each crane was marked with 8cm high color coded plastic leg bands. Each 1982 crane was equipped with new, solar-powered radio transmitters in the 164-MHz frequency range (Wildlife Materials, R.R. 1, Carbondale, Illinois) before being released into the acclimation pen. Transmitters were epoxied onto red, 8cm-high leg bands. Antennas were 19-20cm long and transmitter packages (transmitter and plastic leg band) weighed 60g. Transmitters were attached above the tibiotarsal joint with antennas pointing downward. Each 1982 crane was marked with a red, 6.5cm high plastic neck collar inscribed with an identifying number to aid in visual identification. Leg bands on all cranes were also placed above the tibiotarsal joint.

Crane movements were monitored by visual observations or telemetrically with a portable telemetry receiver (Telonics, Model TR-2) and 2-element yagi directional antennas. Ground monitoring was accomplished using a single yagi or a truck-mounted antenna array (Telonics, Model RA-NS-2) consisting of 2 yagi antennas mounted on a 2.4m tall aluminum mast and a Telonics TAC-5 Combiner to produce a "peak-null-peak" direction indicator. Locations of marked cranes were determined by triangulation. Aerial radio tracking was conducted in a Cessna 152 or 172 with a yagi antenna attached to each wing strut as described by Gilmer et al. (1981). Cranes at the release site were observed with binoculars or spotting scopes from an elevated blind located 200m west of the release pen. Cranes were also observed in the field from vehicles or from cover of vegetation or man-made structures (buildings, etc.). Crane disturbance was minimized during visual observations.

RESULTS

1981 Cranes

Release. Nine parent reared Mississippi Sandhill Cranes (8 birds-of-the-year, 1 one year old) arrived at MSCNWR on 19 January 1981. Full release procedures and activities of the brailed cranes while in the acclimation pen were described by Zwank and Derrickson (1982). Brails were removed from the cranes in 3 groups at approximately 1 week intervals (*Table 1*).

Monitoring. Telemetric monitoring of the 1981 cranes' movements was hampered almost from the beginning by radio failures and loss. The transmitter on crane 601 was lost early in May 1981 when the leg band on which the radio was mounted cracked and fell off. The transmitter on crane 608 failed on 27 March 1981. The antennas on the radios of cranes 604, 605, 606, and 607 broke during August to November 1981. Antenna loss reduced the effective transmission range of these radios to approximately 0.2km. However, the radios on cranes 604, 606, and 607 continued to operate into the summer of 1982.

Movements and Activites. All 9 of the 1981 released cranes remained in the vicinity of the release pen from the time of their release through October 1981 (*Fig. 1*). For a month after release, the cranes confined their activities to the immediate vicinity of the release pen where they fed from the feeders or crop areas and roosted in the wetter parts of the pen or adjacent wet savanna. The cranes, as a flock, moved in March to an area of natural savanna 1km southwest of the pen site. A wooded drainage separates this savanna from the release pen. The cranes returned almost daily to the release pen in the mornings and evenings to feed.

From June to October, the 9 cranes continued to expand their range and eventually used an area of at least 450ha (*Fig. 1*). During this period they were observed or located in restored savannas to the north, east, and south of the release pen, although the birds still used the area of natural savanna west of the pen. On 29 August, cranes 603 and 605 were

Table 1. Release dates for parent reared Mississippi sandhill cranes released at Mississippi Sandhill Crane NWR, Mississippi.

Release year	Crane number	Date arrival at MSCNWR	Date de-brailed	Number of days in pen
1981	601, 603, 604	19 Jan	19 Feb	31
	602, 605, 607, 609	19 Jan	26 Feb	38
	606, 608	19 Jan	6 Mar	46
1982	611, 612	20 Jan	17 Feb	28
	610, 613	20 Jan	2 Mar	41
	614	16 Feb	2 Mar	14

located 2.5km southeast of the pen in a restored savanna; cranes 601, 602, 604, and 607 were also observed or located in this area on various occasions feeding or roosting. However, the majority of crane observations and telemetric locations from June to October were confined to areas within 1.2km of the acclimation pen. All 9 cranes continued to feed at the pen in the mornings and evenings.

During October and November 1981, the released cranes were located several times within or on the edges of mature pine forests. Cranes 601, 602, 606, and 609 were flushed from the margin of a pine forest on 1 November and 602 was observed on 13 and 20 November 0.7km from the release pen within the interior of a pine forest. Drought conditions from August through November 1981 left the wet meadows and most of the drainages on the study area completely dry; lack of water in the savannas may explain the cranes' use of the pine forest where grassy depressions still contained available water. During October and November, crane 602 was often alone.

Few telemetric locations were collected from October 1981 through February 1983 because of malfunctioning transmitters. Visual observations recorded during this time were mainly at the release pen.

Cranes 601, 606, 607, and 608 were found 3.5 and 4.2km northeast of the release pen on 15 and 16 December 1981, respectively, within a mature pine forest bordered on 2 sides by the Bluff Creek and Bayou Castelle marshes (*Fig. 1*). By 19 January 1982, however, the cranes were observed back at the release pen. They continued to visit the release pen regularly to feed during January and February 1982. Cranes 601, 606, 607, and 608 were often observed flying to the pen area from savannas south and southwest of the pen, and were possibly utilizing these areas as roosting or loafing sites. These 4 cranes continued to feed at the release pen through February 1983, and observations indicated that the birds remained on lands surrounding the release pen.

Crane 604 remained flocked with 601, 606, 607, and 608 from November 1981 through May 1982, but left the refuge on 24 May and was not seen again until 7 February 1983, when 604 and a wild crane were observed feeding at the release pen. On 26 and 27 February, crane 604 was located with wild cranes on improved pasture at the Freeman Farm, 5.8km northeast of the release site (*Fig. 1*).

Crane 602 was last seen on the MSCNWR on 20 November 1981, and was not located again until 29 January 1982 when we saw this bird feeding with 15 wild cranes at the Bossarge Farm, 5.2km northeast of the release pen (*Fig. 1*). Crane 602 was again located at the Bossarge Farm on 5, 6, and 10 February 1982, and at the Freeman Farm on 29 January and 5 February 1982.

Crane 602 shifted its activity center during the spring of 1982 to an area 13km northwest of the release pen (*Fig. 1*). Aerial telemetric locations of 602 in this area from 4 May to 5 November indicated that 602 ranged over an area of at least 530ha, reaching a maximum

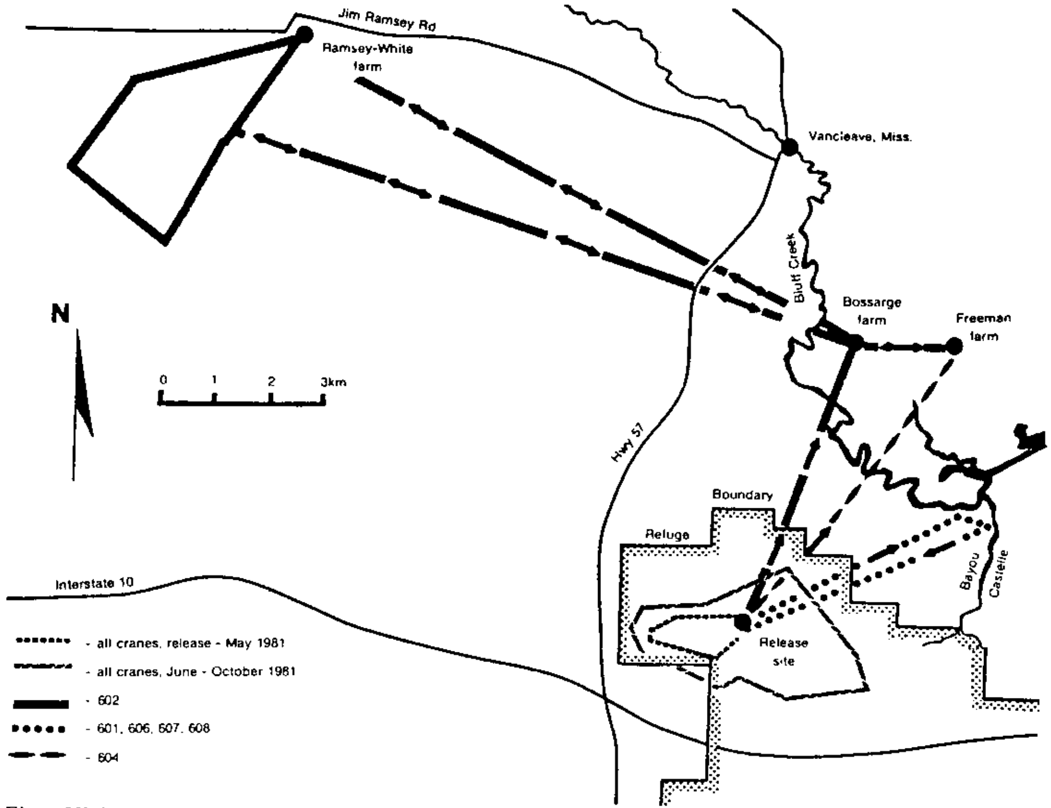

Fig. 1. Minimum movements from 20 February 1981 through February 1983 of 9 parent reared Mississippi sandhill cranes released 19 February - 6 March 1981 at Mississippi Sandhill Crane NWR, Mississippi.

distance of 14.3km from the release site. Crane 602 was located at the Bossarge Farm with wild cranes on 17 December 1982. Monitoring 602's movements soon after this date was limited to visual observations due to transmitter failure. From late January through mid February 1983, 602 was seen on 4 occassions feeding with wild cranes in harvested crop fields at the Ramsey-White Farm, 13km northwest of the pen (*Fig. 1*).

Mortality. All 9 of the 1981 cranes survived the first 6 months of release, and 6 have survived through February 1983. Only 2 deaths have been documented: 603 and 605. Crane 603's carcass was found 4 October 1981 on the edge of a wooded drainage 0.8km south of the release pen. Personnel at the USFWS's National Wildlife Health Laboratory (NWHL), Madison, Wisconsin, found extensive bruising on the head caused by a blow from a blunt object. We believe 603 may have collided with a tree while in flight.

Crane 605's decomposed carcass was found 19 November 1981 adjacent to the release pen area. Because the carcass was badly decomposed, the cause of death could not be determined.

Crane 609 was last seen 1 November 1981; current status of this crane is unknown.

Associations. During the first 4 months postrelease, all 9 cranes remained as flock. From June through October 1981, specific affiliations between certain cranes became more apparent.

The earliest apparent affiliation between any of the 9 cranes was observed between 603 and 605. These 2 cranes were more frequently found in association with each other than any of the other 1981 cranes during the period August through September 1981. Although all 9 cranes continued to feed together at the release pen through September, 603 and 605 were observed arriving or leaving the pen area independent of the other cranes. Crane 602 was occasionally seen with 603 and 605 but was usually alone after early October 1981.

Cranes 601, 604, 606, 607, 608, and 609 formed a distinct group during the late summer and fall of 1981. By December 1982, cranes 601, 606, 607, and 608 were observed feeding together at the release pen, although 607 did not appear closely associated with the other 3 cranes.

Few associations between 1981 cranes and wild cranes were observed from the time of their release through January 1982. The crop unit at the acclimation pen received little use by wild cranes (with the exception of 1 or 2 pairs) during the winter of 1981, limiting interactions between released birds and wild cranes. However, the crop unit was enlarged during January 1982, ryegrass was planted, and more corn was scattered around the unit to attract cranes. Use of the pen area by wild cranes increased through the winter months of 1982. A few wild cranes used the pen area sporadically through the summer and fall of 1982.

Crane 602 was the first of the 1981 cranes to integrate into the native crane population. This crane was observed feeding and flying with wild cranes during January 1982, and was subsequently observed in a nesting area with a wild crane on 4 May 1982. Crane 602 may have formed a pair bond with a wild crane; ground searches of the nesting area revealed several dummy nests. However, there was no indication of actual nesting by the 2 cranes. Crane 602 has since been observed on the winter feeding grounds with wild cranes on 8 occasions from October 1982 through February 1983.

Crane 607 was observed flying into or leaving the pen area with wild cranes on 13 and 16 December. By February 1983, 607 had formed a pair bond with a wild crane and was observed being mounted by the wild crane on 3 occasions.

Crane 604 has integrated into the native crane population, as evidenced by this bird's sustained associations with wild cranes during February 1983.

The remaining 1981 cranes, 601, 606, and 608, were also observed flying with wild cranes on several occasions in December 1982, but no lasting associations with wild cranes were apparent at that time.

1982 Cranes

Release. Four parent reared Mississippi Sandhill Cranes (all birds-of-the-year) arrived at MSCNWR on 20 January 1982. Scheduled delivery of a fifth parent reared crane was delayed because of injuries the crane sustained during a raptor attack at PWRC immediately prior to shipment. This crane (crane 614) arrived at MSCNWR late 16 February 1982 and was immediately placed in the release pen; leg bands and a transmitter were attached the following day.

Initially, the 1982 cranes were frequently observed preening the neck collars and transmitter antennas, but after 2 weeks preening of the collars and antennas seemed to be limited to routine maintenance activities. By 29 February, the antennas of the transmitters on cranes 610 and 613 had broken as a result of preening and constant flexing of the antenna against the ground as the crane walked. Six back up transmitters were returned to the manufacturer to strengthen the antennas and shorten antenna lengths from the original 28cm to 20cm. Modified transmitters were attached to each 1982 crane before the brails were removed (*Table 1*).

Monitoring. Monitoring of the cranes' movements began after each crane voluntarily left the acclimation pen. Cranes 611 and 612 were first observed outside the pen on 1 March and 3 March, respectively. Crane 613 did not leave the pen until 18 March, and cranes 610 and 614 were first observed outside the pen on 20 March.

All transmitters functioned properly until 4 March 1982 when the radio on 614 began to malfunction due to a loose antenna connection. This radio was sending only sporadic and broken signals by 12 March 1982.

Movements and Activities. The 5 cranes centered their daily activities around the release pen area from the time of their release through 8 April 1982 (*Fig. 2*). During this period, the cranes usually fed twice daily at the release pen from the feeders or on scattered corn, and spent the midday hours at the pen or in a recently burned savanna immediately northeast of the pen.

Cranes 610, 612, and 613 flew 1.1km from the pen on 20 March after feral dogs entered the pen area, but returned the following day. Cranes 610, 611, 612, and 613 were located 6 April in a savanna 1.2km northeast of the release pen, but were observed feeding at the release pen earlier and later the same day. Radio-locations and visual observations indicated no distant movement from the release pen area by any of the 5 cranes prior to 9 April.

Cranes 611 and 612 left the release pen area between 9 and 11 April 1982. These cranes were located together on 12 April in a refuge crop unit 3.5km southeast of the release pen (*Fig. 2*), where they remained until 20 April. After crane 611 was killed on 20 April, 612 moved 1.5km southwest to a 14ha fallow crop unit. Radio-locations indicated that 612 remained within or near this crop unit until late June. On 2 July, crane 612 was recovered in an emaciated condition at a shopping mall 7.2km southeast of the release pen (*Fig. 2*). Cranial wounds indicated 612 may have been attacked by a wild pair of cranes that was nesting within 1.0km of the fallow crop unit.

On 9 April, 613 and a wild crane were flushed 1.2km northeast of the pen. Crane 613 was located on 13 April at the Magnolia Hunting Club field, 8.7km northeast of the release pen (*Fig. 2*). Local residents reported seeing 613 on 11 and 12 April near the Bossarge Farm, 3.6km southwest of the field. Radio-locations and visual observations indicated that 613 remained in the immediate vicinity of the Magnolia Hunting Club field until 26 April.

Cranes 610 and 614 remained together near the release pen, but moved from the pen to a savanna 0.6km to the southwest. The cranes continued to feed daily at the release pen until late April.

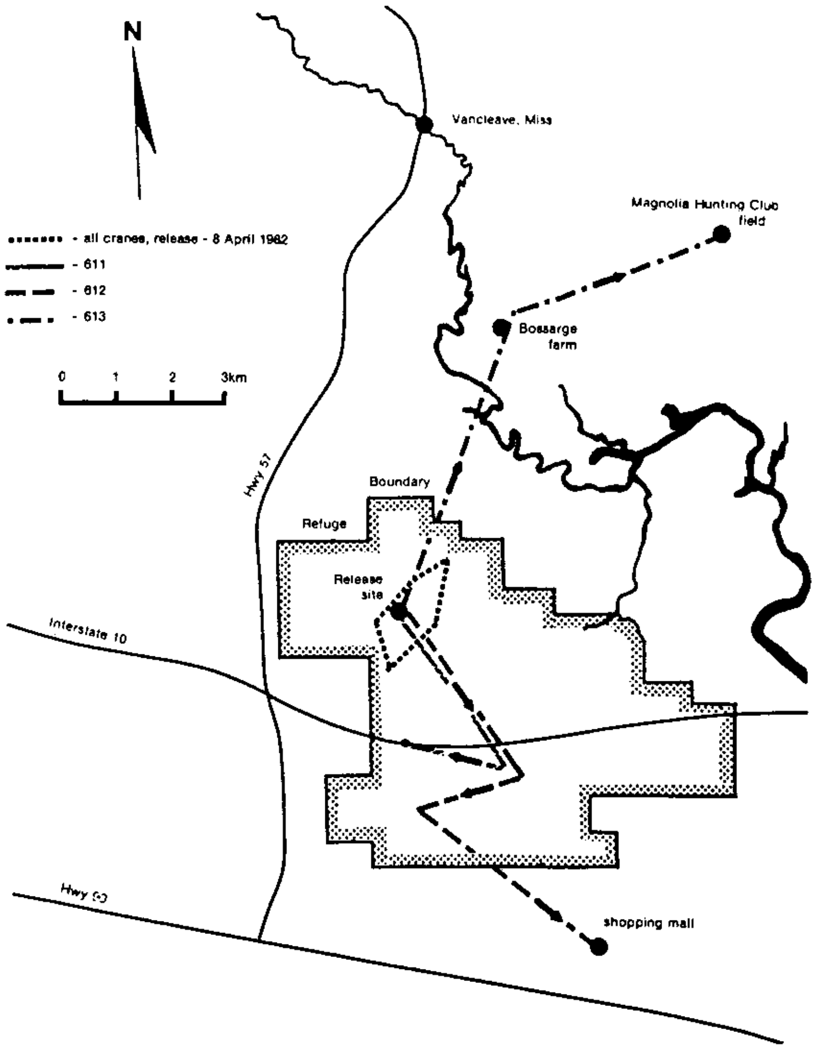

Fig. 2. Minimum movements from 1 March to 2 July 1982 of 5 parent reared Mississippi sandhill cranes released 17 February - 2 March 1982 at Mississippi Sandhill Crane NWR, Mississippi.

Mortality. Only 1 of the 1982 cranes survived more than 2 months after release. Crane 611 was struck and killed on 20 April by a vehicle traveling on Interstate Highway 10, 2.6km south of the release pen. Local residents reported seeing 611 standing on the road shoulder 1 to 2 hrs before the carcass was recovered.

We found 613 dead on 26 April at the Magnolia Hunting Club field. Examination at the NWHL revealed parasitic lesions (pasasite tentatively identified as *Capillaria* sp.) in the tongue, crop and esophagus. Cause of death was believed to be starvation resulting from the tongue lesions that inhibited food ingestion (R.K. Stroud, NWHL, pers. comm.).

Crane 610's carcass was found 30 April on a road 300m west of the release pen. Dog and crane tracks, as well as scattered feathers, indicated a dog attack. A necropsy at NWHL revealed broken ribs, damaged lungs, and puncture wounds in the breast and abdomen. The overall condition of the carcass indicated that 610 had been healthy until the time of death; 610 was last observed alive on 27 April.

Crane 614's badly decomposed carcass was found 1 May outside the release pen in a wet savanna. Cause of death could not be determined, although crushed bones indicated scavenging or a predator attack. We estimated that this bird had been dead 5 to 8 days when the carcass was found.

Associations. The 1982 cranes were in 3 distinct groups prior to April 1982: (1) 611 and 612, (2) 610 and 614, and (3) 613. Both 610 and 614 were observed to be weak fliers, which may have influenced the pairing of these 2 cranes. From the time of release, 613 associated more often with wild or 1981 released cranes than with its cohorts. Crane 613 was observed flying into the pen area with 1981 cranes (601, 604, 606, 607, and 608) on 30 March and 7 April, and was last seen on the refuge with a wild crane on 9 April. Crane 613 was not seen with any other crane after this date.

Cranes 611 and 612 left the pen together and remained as a pair until 611's death on 20 April. No associations were observed between 611 and 612 and wild cranes after these 2 cranes left the release pen area.

Cranes 610 and 614 were observed with wild or 1981 cranes through late April, but no permanent associations were formed.

DISCUSSION

Six of the 9 parent reared Mississippi Sandhill Cranes released at MSCNWR February-March 1981 have survived to January 1983. All 9 birds remained as a flock during the first 4 months postrelease and were not observed to move more than 2.7km from the release pen until 10 months postrelease.

In contrast, only 1 of the 5 parent reared cranes released February-March 1982 survived more than 2 months. These 5 cranes began to associate in 3 distinct groups while still brailed. Three of the 5 cranes left the release pen area 1 month after release and dispersed up to 8.9km.

We believe that early dispersal from the pen site by the 1982 released cranes and failure of these birds to remain as a flock contributed to the lack of success of the 1982-release. These 2 factors may be related to the degree of social bonding that takes place between the cranes prior to release. Cranes released in 1981 were kept together at PWRC for 3 months prior to shipment, and had greater opportunity to develop social bonds than did the 1982 released cranes.

Drewien et al. (1982), working with migratory Greater Sandhill Cranes (*G. c. tabida*) in Idaho, suggested that association with other cranes was important for the survival of released parent-reared cranes. The flocking behavior exhibited by the 1981 cranes may have had survival benefits in the absence of associations with wild cranes in reducing the vulnerability of any single crane to predators, and allowing for greater efficiency in locating food items. In addition, without sustained associations with wild cranes, the 1981-cranes had little stimulus to leave the release area where scattered corn and managed habitat provided better conditions for survival than outlying areas.

Rapid integration into the native Mississippi Sandhill Crane population by released cranes was a goal that was not achieved. Slow integration of the 1981 cranes was probably impeded by the social bonding and flocking tendencies exhibited by the released birds. Other contributing factors may include minimal interaction with wild cranes during the winter of 1981, and the late date of release. By March, winter flocks of wild cranes usually have disbanded and mated pairs have become more territorial and aggressive toward other cranes. Recruitment in the wild population is so low that flocks of nonbreeding birds do not exist at the present time. Thus, 1981-cranes had little opportunity for interactions and integration with wild cranes during the first 10 months after release.

Even though 1982-cranes were released during the onset of the breeding season, use of the release pen crop unit by wild cranes was much higher during the late winter months of 1982 than in the previous year and many interactions were observed between wild cranes, previously released cranes, and 1982-cranes while the latter were still brailed in the acclimation pen. The rapid dispersal of 3 of the 1982-cranes after release may have been prompted by these early interactions. The sedentary behavior exhibited by 610 and 614 after release may be attributed to the inability of these 2 birds to fly long distances.

Dispersal of 1982-cranes into areas of unfamiliar habitat probably contributed to the eventual deaths of these birds. Possibly these 3 cranes followed wild cranes from the release pen to outlying areas, only to be abandoned.

These findings suggest that social bonding and flock size may enhance survival of parent-reared Mississippi Sandhill Cranes released during the onset of the breeding season. However, strong social bonding appears to delay integration of parent-reared cranes into the wild flock. An early fall release may result in the parent-reared birds being released during a time when wild cranes are minimally aggressive and most social. This in turn may allow for more rapid integration of released birds into the wild population because of increased opportunities for wild and released crane interactions.

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PROGRESS OF SANDHILL CRANE STUDIES IN FLORIDA

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ABSTRACT

Of 561 cranes individually marked in Florida since 1974, 28% were resighted and 17% were retrapped at least once 6 months or more after initial capture. Tentative figures on survivorship of 93 juvenile birds and 343 adults are presented. From observing wing feather molt of retrapped individuals an aging technique for subadult birds is being developed. Second year birds have a wing molt pattern distinct from other age classes. Insufficient data exists to make conclusions about third year birds. Movements of adult and subadult cranes were evaluated as they relate to age and social status. Except during the late summer and early fall, adult birds tend to be territorial and much less gregarious than subadults.

At the third crane workshop, we presented a study plan for evaluating the feasibility of establishing a non-migratory population of Whooping Cranes (*Grus americana*) in Florida (Nesbitt 1982). This involved transferring eggs of the migrating Greater *G. canadensis tabida* into nests of the non-migratory Florida *G. c. pratensis* subspecies of Sandhill Cranes on Paynes Prairie in north central Florida. The behavior of the resultant subadult cranes will be monitored for 2 years after hatching.

Any long term, goal oriented study produces information not directly related to the ultimate objective. Some of this adventitious information has relevancy to Sandhill Crane management in the United States and may be applicable to other species as well.

METHODS

The primary study called for banding, individually color marking, and radio instrumenting adult and subadult Florida cranes from a stable local population of 100 birds. Many birds had been banded previously (Williams and Phillips 1972, Nesbitt and Williams 1979) and had a known history. We continued this banding effort relying exclusively on drug capture techniques (Nesbitt 1976a). Each bird's wing feathers were dyed when captured to facilitate remigial molt study. Molt, plumage data, and weights were taken again each time a bird was recaptured, enabling us to look at molt and plumage change from year to year. Several individuals, adults and subadults were instrumented with a radio transmitter (Nesbitt 1976b) having an expected battery life of 2 years or more. We monitored nesting activity of adult pairs, long term movements and seasonal movements to establish "normal" behavior as it relates to age. This information is necessary to compare with the movements of the experimental *tabida* young, foster reared by *pratensis* parents.

RESULTS AND DISCUSSION

We have color marked 561 cranes since 1974 and monitored 12 radio instrumented cranes during all or part of 1981 and 1982. Adults (birds over 1 year of age) banded since 1977 and all the juveniles (birds less than 1 year of age) were individually color marked. Results to date of color marked bird sightings, band returns, and recaptures are presented in Table 1. Migratory cranes traditionally return to the same wintering, staging and summering areas. This tendency to use the same area year after year facilitates sightings of color marked individuals and repeated trapping of the same bird. Of the birds marked since 1974, 17% were retrapped 6 months or more after the initial captures, several more than once. Twenty-eight percent were resighted at least once 6 months or more after capture; most were seen more than once. We should emphasize that all conclusions, especially those drawn from the data on juveniles, are preliminary at this time.

Routine trapping operations have produced 49 retrapped birds: 30 adults and 19 juveniles. Checking for the presence of wing feathers dyed during previous handlings, we noted that both primary secondaries and the upper and lower greater primary and secondary coverts were not replaced during a single molt as Lewis (1979) and Layne (1981) also observed. In both subspecies it apparently takes 3 molting seasons (May to August) to completely replace the remiges and greater primary and secondary upper and lower coverts. We have not looked in any detail at the specific wing feathers replaced during one annual molt period, but the two subspecies appear to be similar. From the recapture of known age birds banded as juveniles, it is evident subadults do not replace any flight feathers, secondaries 1-16 or primaries 1-10, during their second year. The buffy-tipped, juvenile outer primary greater upper coverts (10-5) are also retained through this first basic molt, although there is a greater degree of individual variation in the extent of these buffy tips. These two facts combine to make it easy to identify second year birds, since they have an even aged wing and retain some of the buffy-tipped juvenile coverts. As yet, we have insufficient evidence to make any conclusion on what takes place during the third molt season.

The analysis of movement data for Florida cranes did not produce any firm conclusion on the amount of habitat necessary to support a given population of cranes. We divided the year into 3 month periods and found subadults utilizing from as little as 360 acres to as much as 1200 acres during one period with no immediately obvious pattern of use. Adult pairs spent most of the year on their territories, except for a period in late summer when territories were abandoned and the birds became unusually social.

Nonbreeding Florida cranes mix freely with flocks of greaters, both on roosting and feeding sites. Wintering flocks of greaters contained both nonbreeders and pairs with young, and the nonbreeding Floridas are accepted in these flocks without apparent difficulty. Adult Florida pairs were less inclined to associate with these flocks. They may use the same site for feeding and roosting, but usually remained aloof from the flock and were quite aggressive toward other cranes. This aggressiveness increased from late January to early March, as nesting approached, and continued until midsummer if young were produced. During late summer, this aggression dropped markedly and birds of breeding status as well as nonbreeders became quite social. This social period lasted 6 weeks or more, until fall arrival of greaters began in October or early November. It is possible that during this period pairs are formed, as Walkinshaw (1973) has speculated. Pairing during this time would also prevent pair formation between the two subspecies. Ephemeral pair bonds between subadults of different subspecies developed for a few weeks during the fall and winter. Once a pair bond has formed and heen cemented in the Florida cranes, the pair remains on the territory most of the year, except for the late summer social period. This period may serve as a time of pair reinforcement or change. Interestingly, this social period overlaps the time of remigial molt in breeding cranes in Florida. During this molt we have not seen complete flightlessness, but there is a reduction in flying ability. There may, therefore, be some protection value to reduced aggression levels and to flocking during the period of remigial molt.

Table 1. Number of cranes known to be alive (number possible / %) X number of years since capture.

	6 Mo. - 1 Year	1 - 2 Years	2 - 3 Years	3 - 4 Years	4 - 5 Years
Juvenile (1) (N-93)	30 (93-32%)	20 (55-36%)	12 (34-35%)	9 (17-53%)	4 (5-80%)
Adult (2) (N - 343)	213 (343-62%)	136 (260-52%)	86 (157-55%)	58 (148-39%)	38 (117-32%)
	5 - 6 Years	**6 - 7 Years**	**7 - 8 Years**	**8 - 9 Years**	**9 - 10 Years**
Juvenile (1) (N - 93)	----	----	----	----	----
Adult (2)	26 (104-25%)	16 (98-16%)	10 (57-18%)	5 (57-9%)	2 (22-9%)

(1) Juveniles are birds less than 1 year old when banded.
(2) Adults are birds older than 1 year when banded.

Habitats utilized by Florida cranes and wintering greaters varies through the year. During fall and early winter, the cranes depend almost exclusively on open marsh areas, while during late winter, spring, and summer they are found most frequently on upland sites,mostly improved pasture or agricultural areas. This mix of habitats suggests we can not be complacent with preserving quantities of only one type. Apparently, both uplands and marshes are necessary components in the year-round needs of the Florida crane and wintering greaters. If crane populations are to survive at their current estimated levels of 5,000 to 6,000 Florida cranes and 15,000 to 20,000 greaters, each habitat must be preserved in sufficient quantities and proximity to encourage utilization by populations large enough to insure genetic diversity.

Remigial molt as observed in cranes is interesting but not unique. The same interrupted pattern has been described in other larger nonpasserine birds (Brooke 1981, Bloesch et al. 1977, Spofford 1946, and others) that depend on sustained flight, either for long distance movement or food finding. The same advantages for retaining the ability to fly while undergoing flight feather molt probably affected the evolution of molt in cranes. This leads us to an interesting hypothesis: since both the nonmigratory Florida Sandhill and the migratory Greater Sandhill exhibit the same flight sustaining molt pattern, it can be inferred that the present sedentary population may have originated from a migratory one.

About a third of the birds banded as juveniles were seen to age 3 (*Table 1*), but after that numbers are too small to place any confidence in. The data also suggests that a quarter of the birds banded as adults were seen to age 7 or 8. Again, the apparent decline in number after this age may be the result of low sample size. Also, it was not until 1977 that we began marking adults individually. Continued marking, further field study, and the use of subadult identifying characteristics resulting from molt studies will further refine these observations. It will be interesting eventually to compare data from this eastern population, where the birds are not hunted, with that from the western population where hunting does occur. Additional study on the major spring/fall staging area in Wisconsin, Michigan, and Indiana, will further add to the data.

We would like to say again that these conclusions are drawn from a data pool that is expanding as studies continue and may change as more data become available.

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THE SANDHILL CRANE RECOVERY PROJECT IN THE LOWER FRASER VALLEY, BRITISH COLUMBIA

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ABSTRACT

Records from the period 1858-1918 indicate that the Greater Sandhill Crane (*Grus canadensis tabida*) was present as a breeding summer resident in all the major bogs of the flood plain of the lower Fraser River. Pioneer hunting, disturbance and loss of habitat have reduced the population in this area to three breeding pairs in the flood plain of the Pitt River, a tributary of the lower Fraser, and a small non-breeding flock at Burns Bog south of the Fraser estuary. In 1979, 4 cranes were hatched and released from 8 eggs obtained from Grays Lake, Idaho. In 1980, 30 eggs were obtained from the same source and one egg from the Pitt Valley. After losses through injury and feeding problems, 17 fully grown cranes were banded and released in April 1981. Thirteen birds were believed to have migrated. One was found injured at Richfield, Washington, but was later released. In April 1982, at least 7 and perhaps 9 banded cranes returned to the Fraser Valley. In 1983, two pairs of cranes were seen near Burns Bog; in both cases one bird was banded, suggesting successful integration of "Idaho" birds with the wild cranes. One pair of 'Idaho' cranes paired and laid one egg at the ranch where they were raised but the egg failed to hatch.

THE SANDHILL CRANE IN THE FRASER VALLEY

In the lower Fraser Valley, the Katzie Indians inhabiting the shores of the tributary Pitt River included the Sandhill Crane (*Grus canadensis*) among their guardian spirits. They named it "syahaha'w," meaning "superior in everything," and believed that it imparted skill to women in their work. According to a Katzie legend, a supernatural being named Khaals found two sisters digging up Indian potatoes (Wapato or Arrowhead, *Sagittaria latifolia*) because they had nothing else to eat. When the girls laughed and mocked Khaals he transformed them into cranes, henceforth to roam the meadows, and to laugh and dance after they root up the ground just as the two sisters did (Jenness 1955). Simon Pierre, a Katzie Indian born about 1880, recalled his father, Old Pierre, describing the cranes arriving "in thousands" to feed and nest on the flat meadows near Pitt Lake. Whatever their actual numbers were, the arrival of these large birds must certainly have been spectacular, for it made such a deep impression upon the Indians that they called March the "Sandhill Crane month" (Jenness 1955).

Before white settlement brought dykes and drains to transform the lowlands of the Fraser Valley, the Sandhill Crane probably fed mainly in the open, grassy "prairies" kept free of trees and shrubs by the periodic flooding of the Fraser River (North and Teversham

1976). However, it seems to have preferred the more inaccessible bogs as nesting habitat. John Keast Lord, naturalist with the Boundary Commission between 1858 and 1862, described the Sandhill Crane as "very common east and west of the Cascades" (Lord 1866). The checklist published by the Provincial Museum in 1891 stated that it was "tolerably abundant," breeding throughout its range across British Columbia "but chiefly east of the Cascades." The catalogue of 1904 stated that it was "common" throughout the province, breeding "in the interior of the mainland," but by this time it was disappearing from its haunts in the lower Fraser Valley. Allan Brooks reported that the Sandhill Crane had "...bred regularly in a cranberry bog at Sumas up to 1902" but had not nested there for fifteen years. However, it was still breeding near New Westminster in the large cranberry bogs (Brooks 1917). This location could have been on Lulu Island or along the Fraser towards Port Coquitlam.

In the early 1920's, Canon Martin Holdom was told by older parishioners at Surrey Centre that cranes had once been common in the bog between the Serpentine and Nicomekl Rivers. In 1925, Brooks and Swarth included "mouth of the Fraser River" among the isolated localities in the province where the Sandhill Crane still nested. Cumming (1932) described it as "common at Ladner in May." By 1947, Munro and Cowan reported that cranes "formerly nested or occurred in summer...on the southern coast, at Sumas Prairie, Pitt Meadows and Ladner." They stated, "So far as known, the [mainland] coast population is now restricted to Lulu Island...". However, this was not correct; Robert Luscher reported a pair with young on Lulu Island in 1946, but several pairs continued to nest in Burns Bog, Delta, throughout the 1940's.

By the mid-1960's, the number of breeding pairs in Burns Bog had dwindled to two or three, and in 1970 "several low [aircraft] flights over Burns Bog on June 9 to check for nesting cranes revealed only a single adult in the area" (Campbell, Shepard and Drent 1970). Since then a few cranes have arrived there in the spring and have attempted to nest on at least one occasion, but with little success. In the late summer they are joined by another flock that feeds in the meadows beside Burns Bog and flies to loafing areas among the peat cuttings. The cranes all depart in October. The late summer arrivals at Burns Bog are probably the birds that comprise the last breeding population in the lower mainland, nesting in the marshes and bogs of the Pitt Valley. They too are declining.

THE SANDHILL CRANES IN THE PITT VALLEY

There is remarkably little data on the Sandhill Cranes of the Pitt Valley prior to the present decade. Wilma Robinson and her family and friends have kept notes of their observations over the years. In 1975 they identified nine pairs of adult cranes and five birds believed to be immature. Eight of the paired birds nested, but only three pairs reared young, of which four survived to the end of the summer. In 1976 the B.C.Hydro and Power Authority constructed a power line across the valley using helicopters to erect the pylons. The pair of cranes which normally nested nearest to this project failed to do so. Only five nests were found, and only one young bird was seen. In 1977 only two nests were found and a third nest was presumed to be located in the bog west of the road. A pair was seen with one young bird in the Snake Rock area on 11 June, and two weeks later a pair with two young were seen in a blueberry field on the Polder Farm. 1978 brought a further deterioration; only one nest was found and another suspected, and no young were reported. In 1979, two pairs of cranes were seen each with two young. A third pair is thought to have nested in the central marsh but neither nest nor young were seen. A further three adult pairs were present, but apparently they did not attempt to nest. Since 1979 three pairs of cranes have attempted to nest each year but with little success, except in 1982 when single chicks were seen with parent birds on two separate occasions. This year (1983) one pair has been seen with one young.

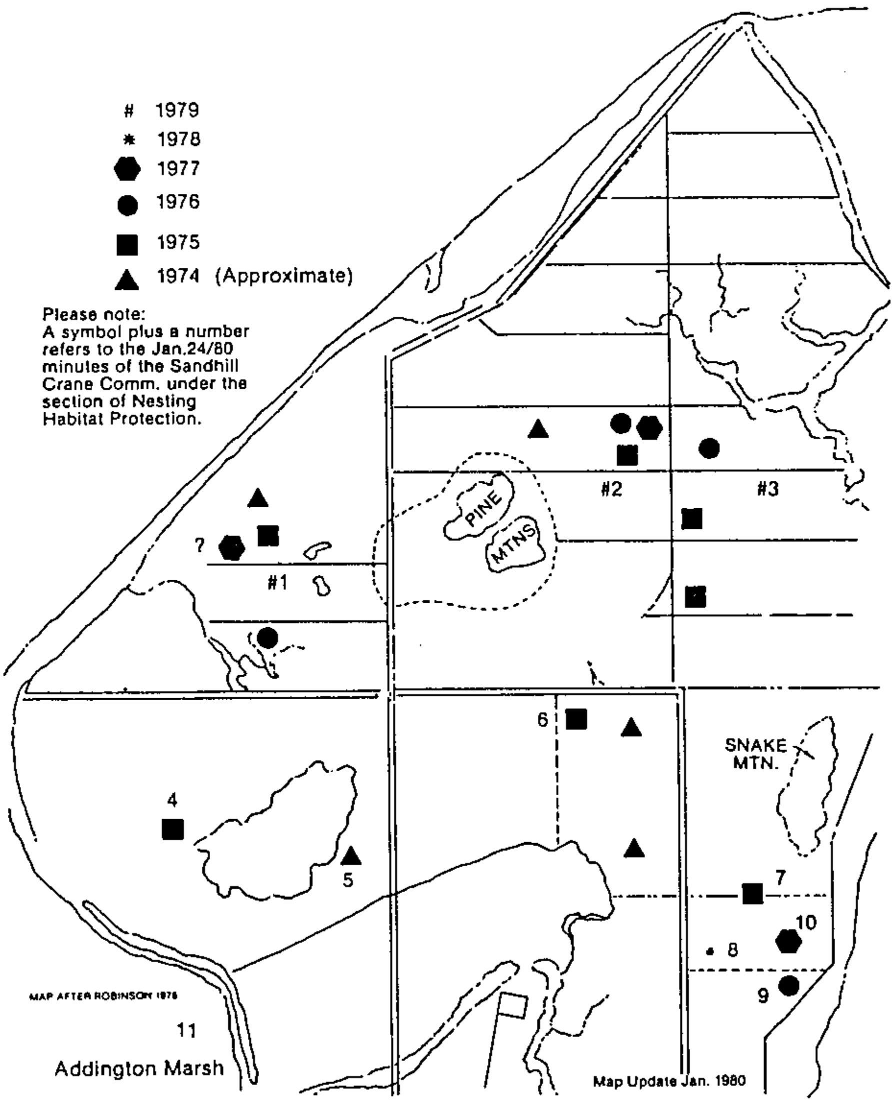

Fig. 1. Crane nest locations, 1974-1977

In summary, between 1976 and 1979 the number of nesting pairs seems to have fallen from eight to three. During that time two nesting areas have been lost to agricultural developments in the Cod Island and Snake Rock areas, and disturbance has been caused by dyke construction and by power line construction projects.

CAUSES AND EFFECTS OF DECLINE

The reasons for the decline and disappearance of the Sandhill Crane were evidently reduction by shooting, disturbance, and, finally, loss of habitat. Oliver Wells (1969) recorded that when his family first settled at Sardis "...the Sandhill Cranes, or wild turkeys as the pioneers called them could be seen regularly as they flew to the marshland at the eastern end of the valley from their nesting grounds on Sumas Prairie. The pioneers thought favourably of them, for they bothered no one and were good eating."

The Migratory Birds Convention of 1916 included a clause closing the hunting of swans, cranes and curlews for ten years. But, of all the states and provinces of North America, British Columbia alone refused to accept this clause, and so it was amended to give this province an open season on these birds. A year later, in a pessimistic reply to an enquiry about his opinion of the Convention, Allan Brooks wrote that the cranes "...must have conditions where they are not much disturbed when at rest." The "large open plains" that they formerly inhabitated, he stated, "are too much disturbed," (Brooks 1918).

It is clear why such a shy bird found survival difficult in the crowded confines of the lower mainland, where by 1905 "...almost every part of the valley was... within two miles of road" (Meyer 1968). The main exceptions were the Delta and Richmond peat bogs and the Pitt Marshes. As long as these areas offered undisturbed havens, a dwindling population of cranes survived by feeding on the neighbouring farmlands and retreating to the bogs and marshes to breed and loaf.

It seems likely that half a century of unrestricted shooting had already sealed the fate of the cranes in the Fraser Valley before protection was finally extended to them. These birds lay two eggs but seldom raise more than one young each year. They are long lived, surviving for twenty to twenty-five years, but they do not begin to breed until they are four or five years old. Annual recruitment is unlikely to be higher than 4 to 8 percent even in large populations inhabiting favourable habitat. As a result it is quite probable that the crane population of the lower Fraser Valley was seriously reduced by shooting and had reached an unviable level by the beginning of the present century, when it was reduced to the colonies at Lulu Island, Burns Bog and the Pitt Marshes. The continued presence of cranes may be due rather to their longevity than to their annual recrutiment.

The decline of the cranes has been hastened in the last four decades by the commercial exploitation of their last remaining habitat in Richmond and Delta, where peatcutting, berry growing and filling has fragmented and reduced the bogs. The mechanisation of peat cutting in Burns Bog may have intensified the impact of disturbance in the last two decades. Drainage and development of adjoining lands has also quickened the plant succession in bogs, where in the past the Indians retarded the process by burning to foster the growth of berries. Recent conservation measures for the restoration of the Pitt Marshes may well have similar effects on the Sandhill Cranes there. The new dykes give raised access to areas formerly difficult to approach. Much of the cover afforded by the tall grasses and Hardhack (*Spiraea douglasii*) to the nesting cranes is reduced or overlooked from the dykes. The lack of means for controlling public use of the area, now that it is virtually an unstaffed public park, guarantees a degree of human activity far in excess of that of peat cutters which has contributed to the reduction of the crane population in Burns Bog.

THE SANDHILL CRANE RESTORATION PROJECT

In February 1980, the Pitt Wildlife Management Area Public Advisory Committee formed a subcommittee to examine the causes of the decline of the Greater Sandhill Crane in the Lower Fraser Valley and to suggest ways of enhancing the local population of this species, especially in the Pitt Wildlife Management Area.

In 1979 a member of the committee, Richard Trethewey, obtained 8 eggs on a permit from Grays Lake, Idaho, and successfully hatched and reared 4 cranes. This success encouraged the committee to obtain permits to collect more eggs in 1980. Richard Trethewey agreed to locate the project at Coniagas Ranch at the south end of the Pitt Valley, not far from the main nesting and feeding areas used by the remaining wild flock of Sandhill Cranes. The project was financed by the British Columbia Conservation Assistance Fund and the Federal Employment Assistance Program. Three students were hired to raise the young cranes. The first task was to construct cages to house the newly hatched cranes under heat lamps. Larger cages and pens were made for the later stages of their development. Valuable advice on diet and rearing techniques was obtained from Roderick Drewien of the U.S. Fish and Wildlife Service, Scott R. Derrickson, Patuxent Wildlife Research Centre, and George Archibald, International Crane Foundation.

Egg collection

On 18 May, Richard Trethewey, Barry Leach and Dr. Roderick Drewien, U.S. Fish and Wildlife Service, collected 30 Sandhill Crane eggs in the marshy valleys around the Grays Lake National Wildlife Refuge, Idaho. After some delay, due to the eruption of Mount St. Helens, the eggs were successfully flown to Vancouver and placed in incubators at Maple Ridge. One egg was also removed under permit from the only nest found this year in the Pitt Wildlife Management Area. Of the total of 31 eggs incubated 26 hatched. However, two chicks died within 24 hours of hatching.

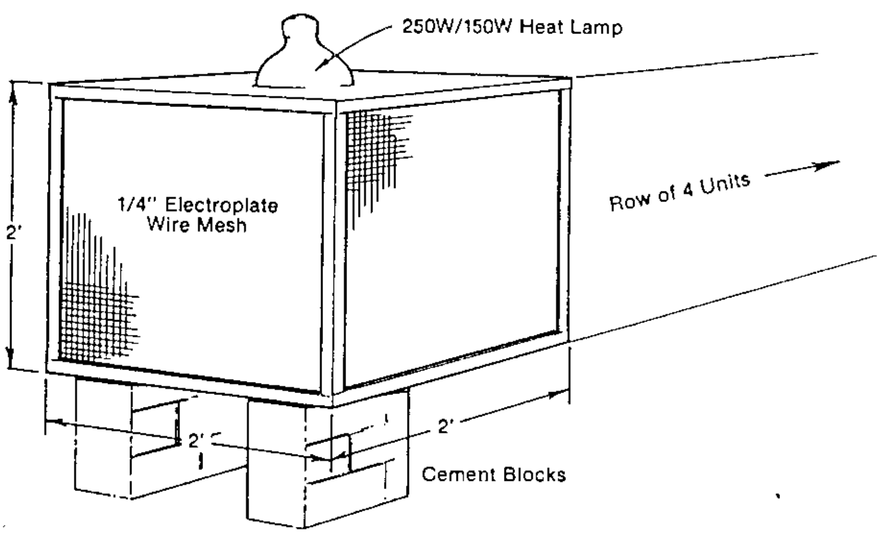

Fig. 2. Small cage for chicks

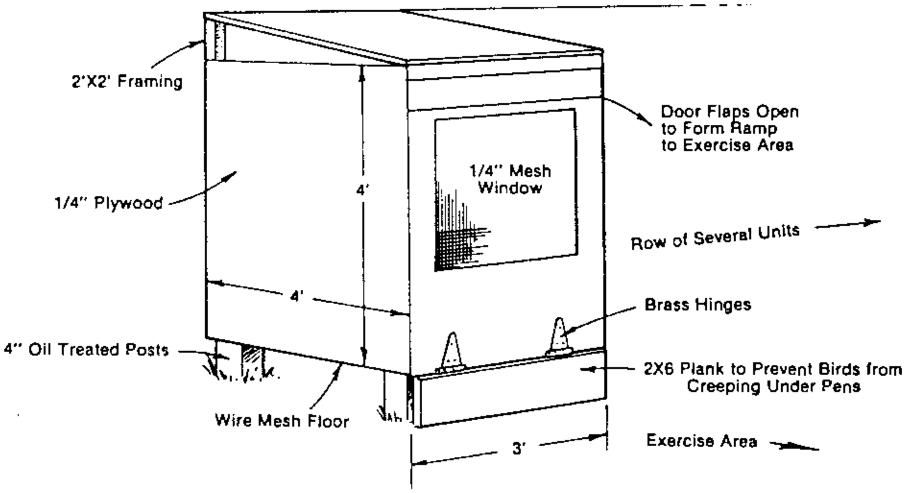

Fig. 3. "Weathering" Cage for subadult cranes.

Feeding

The chicks began to feed readily in response to a red spoon and the addition of meal worms to the Purina Game Bird Chow recommended by the U.S. Fish and Wildlife Service. Hard-boiled egg, egg shell, and vitamin additives were also fed to the chicks. Two birds hatched and raised for three weeks by Harry Hardy of the Western Pheasant and Waterfowl Association were fed turkey starter, and appeared to thrive better on this diet. The rest of the chicks were switched to turkey starter but, perhaps due to the increase in protein, two quickly developed weakness in the legs, collapsed, and died. Several others showed signs of developing leg weaknesses so food was withheld at night and a mixed diet of turkey starter and Purina Chow was adopted. This did not entirely eradicate leg weaknesses; volunteers from local naturalists' clubs gave valuable help in shepherding the birds in daily exercise periods to strengthen their legs. In spite of these efforts, a further bird died from nutrient imbalance and leg weakness. Examination of the leg tissues by local veterinarians revealed that there may have been excessive calcium and vitamins in the diet. Egg shell and vitamin additives were therefore withdrawn.

Aggression

The chicks behaved aggressively during their first three to four weeks. When put out together for exercise and sunlight they attacked one another, sometimes so suddenly and vigorously that the students tending them were unable to prevent injuries. Three chicks died of injuries; one when a barrier dividing a pen was knocked down, and two during exercise periods. However, the birds could not be completely isolated from each other. They had to form flock bonds to reduce the chance of imprinting on humans. The aggressive tendencies were not confined to particular birds but varied daily.

One bird broke its beak on the wire netting of its cage. A veterinary surgeon twice operated on it to secure and straighten the beak with wires. The operations were successful. The bird was able to feed, but the beak remained somewhat deformed.

Further development and release

By mid-August, 19 cranes had attained full plumage and were beginning to fly. However, two more died by September and so the committee decided not to risk allowing the remaining 17 cranes to attempt migration in their first fall. They had had no contact with the wild crane flock, and were probably less strong than wild progeny raised under more challenging conditions with more flight exercise. It was also doubtful that they would be capable of feeding themselves in the wild. They were therefore confined in a pen and released in April 1981 by allowing them to walk out of their pen. They quickly learned to sustain themselves in the fields around Coniagas Ranch, and divided into two groups. These were seen feeding in the proximity of wild cranes, though usually a little separate from them.

One crane died in the winter and one Lesser Sandhill Crane, found injured in Fort St. John, was added to the penned flock, so, including the latter, 17 cranes were released. Three returned or were brought back to Coniagas Ranch, including the bird with the injured bill. One was shot by a youth with a .22 rifle. The remaining 13 birds disappeared at the same time as the wild cranes early in October 1981.

All the released cranes were leg banded, but coloured bands were not used because the necessary permit was not granted. The original intention of using neck bands was dropped due to concern about the increased possibility of injury. However, this resulted in difficulties in distinguishing released cranes from wild cranes in the field.

On 10 November 1981, one of the "Idaho" cranes was found injured at Richfield National Wildlife Refuge, Washington. It was later released. The U.S. Fish and Wildlife Service has been asked to look out for further banded cranes in the states south of British Columbia.

In April 1982 at least seven and perhaps nine "Idaho" cranes returned and were sighted in the field, often accompanying groups of local cranes in the Pitt Valley. The local wild crane flock was believed to consist of three mated pairs and one unmated bird. Two banded cranes seemed to have difficulty in surviving in wild conditions and repeatedly visited urban areas, perhaps seeking Coniagas Ranch where they were reared. These, plus two other cranes that returned freely, have been kept at the ranch to provide a decoy flock for other cranes that find difficulty in surviving unaided.

On 20 July 1982 a ten day old crane chick walked into the yard of a farm immediately to the north of Coniagas Ranch. Since no wild cranes have been known to nest recently on this farm it is possible that this bird was the offspring of one or more of the birds reared and released in 1979. While there is no definite evidence to support this, it seems unlikely that wild cranes would nest so late unless they renested after losing their first brood.

In 1983, 3 wild pairs are believed to have nested but only one nest was found. Cranes with a chick have been seen on two separate occasions.

Meanwhile, of the 32 eggs from Idaho, 21 have been successfully hatched, but 5 of the chicks have died from injuries or leg problems. One pair of "Idaho" cranes attempted to nest in Coniagas Ranch where they were raised, but their egg failed to hatch. The egg was replaced by an Idaho egg, but that too has failed to hatch. Two pairs of cranes have been seen near Burns Bog, south of the Fraser estuary and in both cases one bird of the pair was banded. This suggests that there has been some measure of successful integration of the introduced birds with the local wild cranes.

The Committee met in November, 1982, and decided that the programme has been sufficiently successful to justify application for further permits to obtain another batch of eggs from Idaho in 1983.

The following more detailed publications are available from the Institute of Environment Studies, Kwantlen College:

R.G. MacDonald. "An Account of the Techniques employed by the Sandhill Crane Recovery Project in the Captive Propogation of Greater Sandhill Cranes." Sept. 1980.

B.A. Leach. The Sandhill Crane in the Lower Fraser Valley. New Westminster, B.C. 1979.

and from the Provincial Museum, Victoria, B.C.

B.A. Leach. Waterfowl on a Pacific Estuary: The Natural History of Man and Waterfowl on the Lower Fraser River. B.C. Provincial Museum Special Publication No. 5, 1982 Price $7.00.

RECOMMENDATIONS

(a) The International Crane Foundation has suggested that puppet feeding (i.e. feeding chicks with a sleeve disguised as an adult crane's head and neck inserted through a hole in a board concealing the human feeder) be adopted in the next phase of the project.

(b) Chick diet should avoid over-feeding protein, since this seems to be the major cause of leg collapse.

(c) A permit should be requested for the use of coloured leg bands as these are essential to the observation of the released birds in the field locally, on migration and in their wintering area(s).

(d) The next phase should include a programme of regular field observation of the behaviour of released cranes, especially with regard to their interaction with the wild cranes.

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PRESERVATION OF CRANE HABITAT ON THE PLATTE RIVER, NEBRASKA

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The Great Plains of North America stretch from the Gulf of Mexico to the taiga of North Central Canada (*Fig. 1*). Bounded on the west by the Rocky Mountain steppe and on the east by deciduous forests, these grassy plains form a migration corridor for the Whooping Crane (*Grus americana*) and approximately 75% of the world's Sandhill Cranes (*Grus canadensis*). Midway between the gulf coast and the USA-Canadian border, the Platte River bisects the Great Plains as it flows east from the Rocky Mountains to the Missouri River (*Fig. 1*). The Platte is but one of several rivers that cross the plains, forming a ladder of wetlands used by many species of magratory birds as they move from the wintering grounds along the Gulf coast, Mexico and Central America to the nesting grounds of the northern U.S., including Alaska and Canada and Siberia. Among these rivers, however, the Platte is unique.

Prior to its development for the production of corn and cattle, the Platte flowed through a seemingly endless grassland. Trees were almost nonexistent, victims of prairie fires, an arid climate and grazing buffalo. The active channel of the Platte was wide with well-defined banks. During 80 years of written records beginning with the 1820 Long Expedition, there were no overbank flows recorded along the Platte. The channel was very wide, up to 1600 meters, and except for an occasional wooded island, was nearly free of vegetation (Williams 1978). The bed material of course to fine sands and silts formed sandbars that were constantly migrating downstream (Crowley 1981). The annual late winter ice flows and spring flooding flows caused major downstream movements of the substrate which prevented woody vegetation encroachment on the active river bed.

Adjacent to the active channel were lowland grasslands with sloughs and potholes, remnants of old river channels. These wetlands were filled in late winter and early spring by rising water tables, snow melt and spring rains. By fall, many were dry.

The Platte valley with its nearly unobstructed vistas, shallow and broad river bed with adjacent grasslands and wetlands provided ideal habitat for cranes. The Platte was and continues to be the major spring staging area for Sandhill Cranes in North America. The birds begin arriving in late February and early March. While rivers further north remain frozen, the Platte is usually ice free by this time so the Sandhill Cranes are safe from predators on their river roosts and find abundant food on the meadows and wetlands. The Whooping Cranes stop on the Platte in the spring during April and May and on their way south in October and November.

Up to the beginning of the 19th century, the Platte Valley was a pristine environment occupied by Pawnee, Otoe and Omaha Indians who hunted buffalo and cultivated small patches of corn, squash, pumpkins and beans (Olson 1966). In 1804, President Jefferson

Fig. 1. Midway between the gulf coast and the USA-Canadian border, the Platte River bisects the Great Plains as it flows east from the Rocky Mountains to the Missouri River.

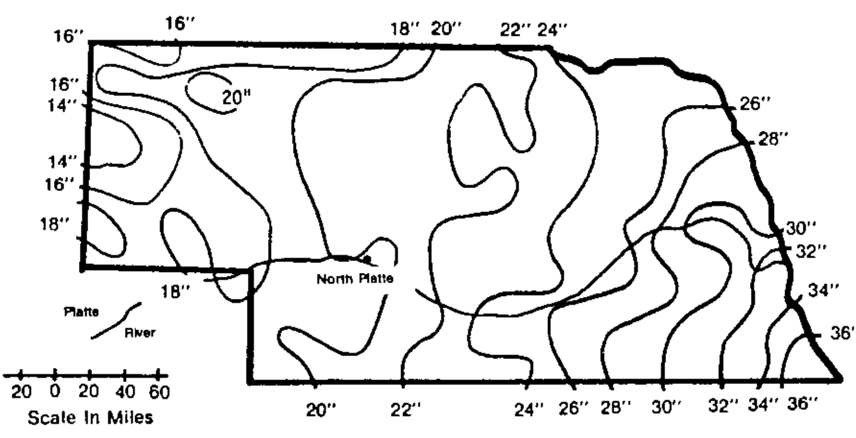

Fig. 2. Annual rainfall isolines across Nebraska.

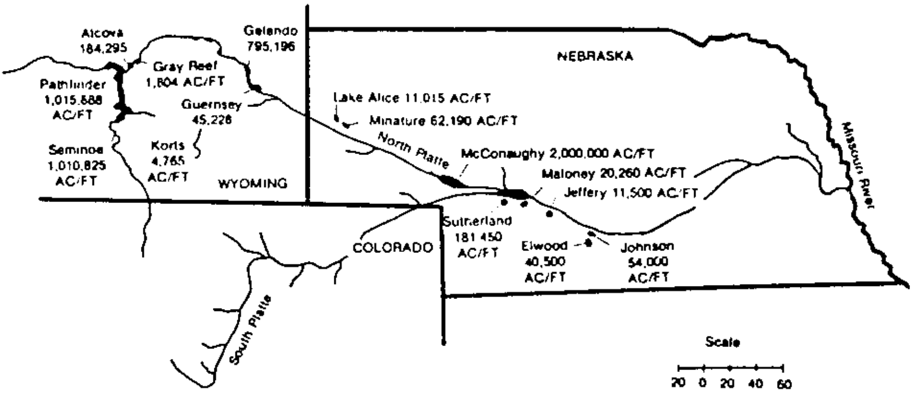

Fig. 3. Water reservoirs along the Platte.

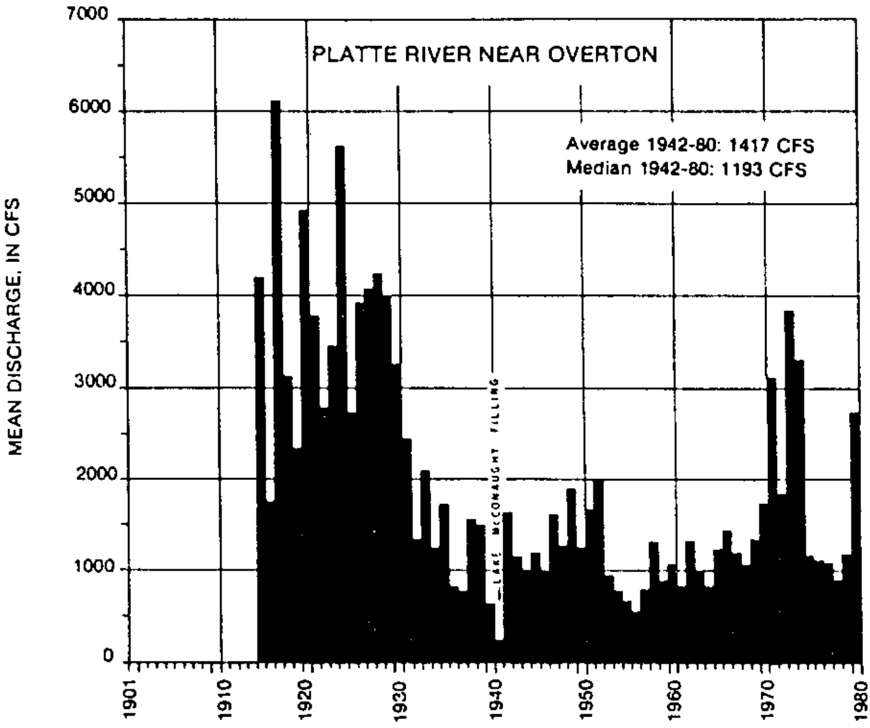

Fig. 4. Average mean flow of the Platte River near Overton, 1901-1980.

Table 1. Classification of Platte River database surface cover types.

Cover Types	Minimum Polygon (acres)	Line Data	Definition
RIVERINE			
(FP) Floodplain			Boundary of historic floodplain
(CH) Channel	0.5	No	Bank to bank inundated channel
(BB) Beach/Bar	0.5	No	Unvegetated sandbar
(HE) Herbaceous	0.5	No	Vegetation under 3.3 ft. (1m) tall in floodplain
(WM) Wet Meadow	10.0	No	Grasslands with emergents or open water in floodplain
(SH) Shrub	0.5	Yes	Woody vegetation 3.3-13 ft. (1-4m) tall in floodplain
(WO) Woody	0.5	Yes	Woody vegetation over 13 ft. (4m) tall in floodplain
UPLAND/RIVERINE			
(EM) Emergents	0.5	No	Emergent wetland species
(OW) Open Water	0.5	Yes	Standing water other than channel
UPLAND/AGRICULTURAL			
(GR) Grassland	5.0	No	Grassland & hayland outside floodplain
(AL) Alfalfa	10.0	No	Alfalfa inside or outside the floodplain
(CO) Corn	10.00	No	Corn inside or outside the floodplain
(OC) Other Crop	10.0	No	Cropland other than corn and alfalfa
(WS) Woods/Shrubs	0.5	Yes	Woods & shrubs outside the floodplain
DEVELOPMENT			
(CD) Commercial	0.5	No	Towns, cities & business development
(UD) Urban	0.5	No	Housing developments
(SD) Single Dwelling	0.5	No	Farmstead and other dwellings
(PA) Paved Road	0.5	No	Paved roads
(GA) Gravel Road	0.5	Yes	Maintained gravel roads
(PR) Private Road	0.5	Yes	Primary private roads
(RR) Railroad	0.5	Yes	Railroads
(PL) Powerline	0.5	Yes	Major transmission lines
(BR) Bridge	0.5	Yes	Bridges within the floodplain
(SG) Gravel Oper.	0.5	No	Active gravel operations

commands enable the user to measure such things as areas of polygons, distances between polygons, and amount of common boundary between specific habitat components. Other commands will allow the user to stipulate a buffer zone around a specific land use type. For instance, if it is determined that Whooping Cranes will not occupy an area within a mile of an active sand and gravel mine, a one mile buffer can be drawn around all the sand and gravel operations in the study area and then, using other commands, the amount of habitat lost can be calculated.

In addition to the 60 Map Overlay and Statistical System (MOSS) commands, habitat models can be used to analyze the relative values of discrete areas. Extensive studies of Sandhill crane biology on the Platte River during their spring migration has enabled the Trust, with the aid of several crane experts from the USA, to develop a Sandhill crane habitat suitability model (Armbruster & Farmer 1982). The model identifies three critical habitat components for Sandhill cranes; grain food, invertebrate food and roosting sites. Grain food is associated with corn and other croplands, invertebrate foods are associated with grassland, haylands and alfalfa fields, and roost sites are associated with river channels. The relative value of these sites is modified by their size, proximity to one another, and the presence or absence of disturbance factors such as highways, bridges, railroads, power lines or houses. The relative value of a roost site is primarily related to width of open channel and the height of adjacent vegetation, although the disturbance factors listed above also impact the roost site's relative value.

Analysis of the data base will enable the Trust to determine relative habitat values of discrete areas and examine the effect of different management activities such as vegetation removal from the river bed. Both the crane model and the data base are completed. Verification of the model is in progress. A report on existing habitat conditions will be completed this year. After completing the habitat condition report, the land base goals of the Trust will be quantified and a program designed to reach the objectives contained in that report will be developed.

The second principal effort of the Trust is to quantify the flows needed to maintain the roost sites and wetlands adjacent to the river and to develop a program to insure flows are maintained. As stated earlier, this is a most complex and politically volatile issue. In Nebraska, 80% of the billion dollar annual corn crop is irrigated. Irrigation more than doubles the state's crop production. Because of the advantages of irrigation, private interests along the river are proposing schemes to divert more water from the Platte to develop even more irrigated land. The amount of water needed to meet all of the presently proposed projects exceeds the remaining flow of the river. Although there is no present market demand for existing production, the promise of future profit motivates these project sponsors to continue their efforts. These project sponsors and their supporters are the dominant political force in the state of Nebraska. At the same time, there probably is a majority of Nebraska citizens who support the maintenance of instream flows for a variety of uses including groundwater recharge, domestic water quality maintenance, hydropower, and wildlife uses, Proponents of maintaining instream flows are led by national environmental organizations. They have used various laws and lobbying techniques to prevent government action that would promote water diversions. The final result of this conflict is uncertain, however it will likely continue until a coalition of water developers and instream flow advocates develop a compromise water management plan. Should such a coalition be formed, they will probably be able to get the legislative and economic support needed to implement their plan. For the Trust to effectivly participate in such a coalition building effort or to endorse a particular proposal for management of Platte River flows, the Trust must know what flow regime is required to maintain the crane habitat. The Trust has initiated a series of studies to quantify these flows. These efforts are based on an analysis of the extensive biological information developed by the U.S. Fish and Wildlife Service (Krapu 1981) and several basic research reports developed by the U.S. Geological Survey (Crowley 1981, Kircher 1981, Karlinger et al. 1981, & Hurr 1981).

The objectives of these studies are to:

1. Define the flows needed to create optimum roosting conditions during the crane migration.
2. Define the flows needed to scour a channel sufficiently wide to provide for optimum roosting conditions.
3. Define the flows needed to maintain the groundwater regime associated with optimum water levels on the lowlands and wetlands.
4. Define the flows needed to maintain aquatic organisms used as forage by cranes and other migratory birds.

Much of the effort described above is necessary because these land and water resources are in short supply and there is keen competition for them. In addition, the competitors for these resources enjoy a dominant economic and political position. The need for additional information has not, however, precluded the Trust from undertaking operational programs to promote the welfare of cranes.

The most valuable habitat for cranes is known and the Trust has taken action to preserve some of it. In partnerhship with The Nature Conservancy, the Trust has purchased a twothousand acre tract of grassland and the adjacent 3½ miles of river channel. The first step in developing a management plan for this tract was a species inventory. The general habitat types represented were 415ha (1,026 acres) of wetland meadow, 221ha (545 acres) of hayland, 42ha (103 acres) of alfalfa and 23ha (23 acres) of corn. A total of 262 plant species were identified (Kolstad 1981). Thirty-three species of fish (Cochnar & Jensen 1981), 10 herptiles (Ballinger 1980), 23 species of mammals (Springer 1981), 135 families of insects (Ratcliffe 1981) and 177 species of birds (Hay & Lingle 1981) were recorded. Two species considered endangered by federal authorities, bald eagles and peregrine falcons, were observed, as well as least terns, which are considered a threatened species by state authorities.

Following the surveys and a review of available information on cranes, a management plan for the tract was developed (Lingle & Boner 1981). The plan is designed to provide optimum conditions for cranes, however the needs of other species were considered in the development of the plan. Cattle-grazing and the cutting of hay are an integral part of the management. In addition to their value in manipulated vegetation production and stature, they provide an income for the long-term maintenance of the property. The Trust has purchased other lands and conservation easements on other portions of the river to provide additional habitat protection. One farm, consisting of 400 acres of cropland and a very valuable but rapidly deteriorating roost site was purchased. A portion of this farm was subsequently traded for a conservation easement on nearby grasslands. The easement prohibits the landowner from converting the grassland to cropland. Most of the remaining cropland purchased was converted to alfalfa production. This area will be studied to determine if it can produce invertebrate food at rates similar to grassland. The remaining cropland, about 100 acres, is being placed into a crop rotation program with limited pesticides, chemical fertilizers and herbicide applications. The purpose of this effort is to determine the economic practicality of such a farming method and its ability to produce grain and invertebrate food for cranes.

A second area where the Trust is implementing management practices is roost rehabilitation. It is well known that in those areas where vegetation has become established, it will continue to grow and spread until the roosting habitat is destroyed. No natural forces now operating will reverse this trend, thus some form of rehabilitation is necessary if the roost habitat is to be maintained or restored. A series of experiments that utilize various mechanical and chemical methods of vegetation removal and control has been implemented (Currier 1984). The techniques being studied utilize brush cutters, disc plows and herbicides. Approximately three miles of river were cleared in the summer of 1982. Additional clearing methods and methods to maintain cleared areas will be studied in 1983 and subsequent years.

Even in the water management area, some operational programs have been explored.

Although the precise flow regimes required are not known, it is obvious that any management plan that would maintain or increase existing flows in the river would be desirable. The Trust recognizes that any agricultural user located downstream of the habitat area who gained a legal claim to divert water from the river would by his action prevent that amount of water from being diverted upstream.

The Trust sought and found a downstream agricultural user who might be interested in developing a water diversion project and devised a joint water development scheme. Included in this scheme is a reservoir located upstream from the habitat area. This reservoir would be used to store water during periods when the natural flow of the river exceeds the needs of the habitat area and/or needs of the downstream agricultural users. When the natural flows fall below the required instream flows, the stored water would be released to maintain the crane habitat. Natural flows and stored waters would be diverted at a point downstream of the habitat area. The Trust and two other sponsors applied for the right to store and divert 315,000 ac ft of water in accordance with this scheme. State administrative hearings on this application will be held in the next few months. If a water right is granted, economic, engineering and environmental feasibility studies will be conducted. If feasibility is demonstrated, funding will be sought, and construction will follow.

The preservation of crane habitat on the Platte River involved complex biological, economic and political issues. The biolocial issues are related to a definition of the habitat components required by cranes and a quantification of each component, particularly water. The information and analysis required to adequately address this issue will be completed within a year's time.

The economic issue is more complicated and volatile. Maintaining instream flows will reduce the amount of water available to upstream agricultural developers. The economic question is how much of the perceived economic loss will be offset by the economic values of instream flows (i.e. power production, groundwater recharges, water quality maintenance, hunting and fishing) and downstream diversions for industrial and agricultural uses. Quantifying the costs and benefits of alternative water management plans is necessary if this issue is to be adquately addressed. The magnitude of this problem is so great and its economic impacts so important that any study undertaken in this regard must be conducted by a body trusted by the majority of the special interests involved. Such an effort was initiated by an agency of the Nebraska State government in mid-1982. The study utilizes the Adaptive Environmental Assessment and Management method (Holling 1978). The process involves members of each special interest, state agencies involved in studying or administering water rights or projects and local government agencies concerned with water. The participants are suspicious of one another and therefore skeptical about the outcome. Funding is also a problem. It remains to be seen how successful this effort might be. A number of alternate water management schemes that define costs and benefits to the satisfaction of all participants must be produced if the effort is be considered even a modest success. The process would be a resounding success if a single water management plan was developed which all or at least a majority of the participants could support.

While the biological and economic issues revolve around objective analyses of costs and benefits, the political issues also involve power, prestige, and personal gain. While the analysis of biological and economic issues can be forced into public view and therefore be examined objectively, much of the political process is hidden behind closed doors. The motivation of the political forces is frequently obscure and therefore difficult to address. For example, the supporters of a particular water development project may proclaim its public value to the citizens of Nebraska while their principal interest is in escalating land values or selling bulldozers. The number of people with such hidden motives is probably not large but they may be politically influential. If the citizens of Nebraska and the nation are ignorant of the costs and benefits of various water allocation schemes, then individuals with powerful political influence will dominate the decision making process to benefit their own special interests. If, however, the citizens are well informed about the costs and benefits of various alternatives, then they will play the dominant role in the decision making process. Under the second scenario, crane habitat will likely be preserved. In a survey of farmers and other citizens in the Big Bend area, the need to maintain existing wildlife habitat was placed before the need to develop additional irrigated land. One of the principal thrusts of the Trust and all others interested in wildlife must be public education. Only with an informed electorate, will a balance of resource use occur that includes both the preservation of wildlife and maintenance of economic interests.

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PROPOSAL FOR PLATTE RIVER CRANE HABITAT ASSESSMENT (Cooperative Agreement # 14-16-0009-81-999) FOR PLATTE RIVER WHOOPING CRANE HABITAT MAINTENANCE TRUST

U.S. Fish and Wildlife Service
Western Energy and Land Use Team
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INTRODUCTION

The Platte River Whooping Crane Habitat Maintenance Trust (Trust) is a private, nonprofit organization formed to restore and preserve migratory bird habitat in the Big Bend area of the Platte River in Nebraska. The species of primary interest is the whooping crane; however, the Trust is charged with protecting habitat for all migratory birds using the Big Bend area, including sandhill cranes, ducks, geese, least terns, bald eagles and others. The Trust was formed in 1979 as an element of the settlement of litigation regarding the potential effects of the Grayrocks Dam and Reservoir in Wyoming on the Nebraska habitat of the whooping crane and other migratory birds.

The court settlement which created the Trust allowed considerable discretion in meeting its purposes. The Trust may fund projects or activities which include, but are not limited to, management of crane habitat, acquisition of land or interests in land, conduct of scientific studies, and acquisition of rights to water or water storage. The settlement, however, explicitly required the Trust to:

(a) Establish a written habitat monitoring plan which can be used to describe changes in riparian, wetland, cropland, and island habitats within the Big Bend area of the Platte River and other segments of the North Platte River utilized by sandhill and whooping cranes.
The plan shall be reviewed by appropriate federal, state, and private agencies concerned with the natural resources of the Platte River in these areas;

(b) Institute the habitat monitoring plan under the supervision of a technical steering committee comprised of qualified ecologists and water resources specialists selected by the Trust; and

(c) Prepare habitat monitoring reports for public distribution on a regular basis.

Early in 1981, representatives of the Trust contacted the Western Energy and Land Use Team (WELUT), U.S. Fish and Wildlife Service (FWS), to explore the feasibility of developing a computerized geographic information system database for use in the Trust's habitat monitoring plan. It was perceived that such a database would include pertinent geographic information coupled with the analytic capabilities to support the Trust's role in habitat preservation and management. Pertinent geographic information was defined as a classification of the location and amount of selected land cover types and features influencing various species of migratory birds utilizing the Big Bend area of the Platte River and portions of the North Platte River. The approximate area of interest was some 800-1000 square miles occurring in portions of 11 Nebraska counties. Analytic capabilities were defined as the storage and structured manipulation of such information.

The geographic information system database will consist of a computerized data bank accessible both on site and off site by computer software programs. The basic unit in the system is a rectangular grid cell having specific values as assigned for each surface cover type under consideration. In essence, the database will consist of a series of data planes or themes (e.g., vegetation types, croplands, river channels, roads, bridges, etc.), obtained from color infrared aerial photography which has been manually interpreted, digitized, and finally transformed into a grid-cell format compatible with computer storage, manipulation, and analysis techniques.

Analytical capabilities of the digital database are founded on the computer's ability to access and overlay or merge the stored data planes containing the spatial information of interest to answer a variety of questions as directed by the operator. The Trust should be able to answer questions similar, but not limited to, the following examples:

1. How many acres of corn, alfalfa, and other croplands exist between bridges x and y?

2. How many acres of grassland exist between bridges x and y, and where is it located?

3. Where do river channels ≥250 yards exist between Overton and Chapman?

With digital database, answers to these and similar questions can be obtained in both graphic (map) and tabular forms.

The concept of habitat usually encompasses the needs of a particular species or group of species. Therefore, if the Trust was to use such a geographic information database to assist in habitat preservation and management, some focal point was needed. It was determined that the habitat requirements of sandhill cranes would be an appropriate focus for such an information base. A workshop was subsequently held in early June, 1981, at the WELUT office for the purpose of identifying the habitat requirements of sandhill cranes, and formulating this information into a habitat model capable of functioning from data obtainable from aerial photography and existing information (e.g., USGS maps). The model was subsequently presented to a group of international crane experts for their review and input (Armbruster & Farmer 1982).

Coupling the sandhill crane habitat model to the geographic information system database, via appropriate software, will enhance the utility of both components. Once accomplished, the Trust should be able to answer questions similar to the following examples:

1. Where are sandhill crane river roost sites between bridges x and y, and how many acres of corn occur within 3.5 miles of each roost site?

2. How many acres of wet meadow between bridges x and y would be available for crane use if secondary roads were closed?

3. How many acres of river channel would be available between bridges x and y for sandhill crane roosts if all shrubs were removed?

The capability to rapidly answer such questions would greatly enhance the Trust's role in habitat preservation and management.

Therefore, the purpose of this document is to present a detailed proposal for:

1. Development of a comprehensive, computerized database of the land cover types and features influencing various species of migratory birds using the Sutherland to North Platte area of the North Platte River and the Big Bend area of the Platte River; and

2. Evaluation of the performance of a habitat suitability model for sandhill cranes.

METHODS AND PROCEDURES

This proposal concerns itself with: (1) procedures for, and costs of, development of a geographic information system database specific to the Trust's area of interest in central Nebraska; and (2) procedures for, and costs of, evaluation of a habitat suitability model for sandhill cranes. Although independent entities, the database and the model each serve to complement and enhance the utility of the other.

UNITS OF CONSIDERATION

The proposed information base will encompass some 100 plus miles of the North Platte and Platte Rivers. The North Platte study area begins at Sutherland, located approximately 30 miles downstream from Kingsley Dam on Lake McConaughy, and proceeds downstream about 20 river miles to North Platte, Nebraska. The Platte River study area begins at Overton and proceeds downstream for 80 river miles to Chapman, Nebraska. Utilization of such a large information base is facilitated if some method of segmentation is employed. We suggest that initial information analysis segments utilize bridge crossings as boundaries. *Table 1* lists the bridge reaches along the North Platte and Platte Rivers suggested as the initial data analysis segments. If each bridge reach is analyzed independently, 13 data analysis segments will be required.

Table 1. North Platte and Platte Rivers bridge reaches.

Segment #	From	To	River Miles
	North Platte River - Sutherland to North Platte		
1	Sutherland Bridge	Hershey Bridge	6.1
2	Hershey Bridge	North Platte Bridge	14.2
		Subtotal	20.3
	Platte River - Overton to Chapman		
1	Overton Bridge	Hwy. 183 Bridge	8.4
2	Hwy. 183 Bridge	Odessa Bridge	6.7
3	Odessa Bridge	Kearney Bridge	8.3
4	Kearney Bridge	Hwy. 10 Bridge	7.0
5	Hwy. 10 Bridge	Gibbon Bridge	5.6
6	Gibbon Bridge	Shelton Bridge	6.3
7	Shelton Bridge	Wood River Bridge	8.4
8	Wood River Bridge	Alda Bridge	5.2
9	Alda Bridge	Hwy. 281 Bridge	6.5
10	Hwy. 281 Bridge	Hwy. 34 Bridge	7.2
11	Hwy. 34 Bridge	Chapman Bridge	10.5
		Subtotal	80.1
		Grand total	100.4

Any segmentation scheme will have certain problems; however, this approach seems the most practical for several reasons. First, crane mobility studies (USFWS 1981) indicate that the average utilized river reach covered 7.3 miles. If the suggested combination of segments occurs, the average distance between bridges ranges from 7.3 miles along the Platte River, to 10.1 miles along the North Platte River; distances compatible with crane home range estimates. Secondly, bridges serve as reference points for agencies conducting crane censuses. Compatible data sets will therefore exist for model evaluation. Finally, local residents are already familiar with these landmarks and tend to think of the river in terms of segments bounded by bridges. Compatible terminology should assist the Trust in communicating with the public. If this initial segmentation scheme becomes impractical at some future time, the geographic information system will have the ability to treat any other segmentation scheme.

Photo Acquisition and Recommendations

A baseline year of 1982 will be used for photo-interpreted information along the Platte River (Overton to Chapman). A 1976 baseline year will be used for the North Platte River area (Sutherland to North Platte). Existing FWS 1976 color infrared, 1:24,000 scale photography will be used for the North Platte area. New photography must be obtained during the 1982 summer for the Platte River area.

Acquiring photography for the Platte River and adjoining area will be a major objective for the 1982 summer. In order to obtain the photography as soon as possible and during the 'best' time of the month, it is recommended that the Trust contract directly with a contractor specializing in aerial photography. This will provide the Trust with direct control over the date of acquistion and other specifications. The WELUT will assist the Trust in designing photo mission specifications and in setting up the contract.

Potential contractors include the following companies and corporations:

Aerial Photo Service, Inc.
324 Main Mall
Tulsa, OK 74103

Aero Metric Engineering, Inc.
4708 North 40th Street
Sheboygan, WI 53081

Intrasearch
5351 South Roslyn Street
Englewood, CO 80111

Horizons, Inc.
P.O. Box 3134
Rapid City, SD 57709

Hurd, Mark Aerial Surveys, Inc.
345 Pennsylvania Avenue S
Minneapolis, MN 55426

Deseret Services Company
5833 Underwood Avenue SW
Cedar Rapids, IA 52404

Lietz Company, The
9111 Barton, Box 2934
Overland Park, KS 12901

Wilson & Company Engineers
P.O. Box 1648
Salina, KS 67401

Two potential contractors were contacted to obtain cost estimates for obtaining the aerial photography for the Platte River area. The following specifications were used for obtaining the estimates:

1. Scale: 1:24,000
2. Type: Color infrared
3. Total path width: approximately 9 miles
4. Total path length: 80 river miles
5. Frame lap: 60%
6. Line lap: 20-30%
7. Number of flight lines required for stereo coverage (4)
8. Photo frames cut and jacketed

The companies were:

Intrasearch (303-741-2020)
5351 S. Roslyn Street
Englewood, CO 80111

Contact: Jack Witt Cost Estimate: $6,000
Product: Original transparencies on the roll

and

Horizons, Inc. (605-343-0280)
P.O. Box 3134
Rapid City, SD 57709

Contact: Dave Webb Cost Estimate: $9,000
Product: Original transparencies on the roll

From the date of photo acquisition, the companies estimated a turn around for processing the film, and its delivery, of ten and fifteen working days, respectively. Based on these estimates, if the photography was obtained the last week of July, and it is of acceptable quality, manual photo interpretation could begin on September 1, 1982.

Classification Scheme

Table 2 contains the proposed classification system for use in establishing a baseline geographic information system database specific to the Trust's area of interest. This classification was discussed with the Trust on November 16, 1981, and January 12, 1982, and tentatively approved. There may still be some revisions or additions required for the North Platte area.

EXPERIMENTAL PROCEDURES

The following discussion focuses on procedures suggested to evaluate performance of the sandhill crane habitat model. It should be noted that such an evaluation will necessitate concurrent scrutiny of the adequacy of the information database.

Procedures employed in evaluating the habitat model's performance focus on a comparison between model output, and sandhill crane use of the area of interest. The procedure will exploit both present and future information based on the 1982 baseline database.

Pre-spring 82

There is a large existing body of information concerning the Platte River and its resources; much of it collected within the last five years. However, since it was not explicitly collected for use in evaluating sandhill crane habitat models, some manipulation and adjustment of the data will be required before use for this purpose. Instead of waiting for new photography to be interpreted it is suggested that preliminary model evaluation begin immediately. This can be accomplished through the selection and use of small, manageable study areas for which existing photography and crane-use information is available. The process is outlined below.

For the initial prespring '82 phase of the study, we propose to select at least five study areas from existing photography. Study areas should consist of river reaches, approximately 8 miles in length, and the adjacent terrestrial habitat out to a maximum perpendicular distance of 3.5 miles, if photo coverage exists. The study areas will be located along the entire area of interest in relation to present crane-use patterns. Following this approach, three sites will be located in Staging Area 1, between Kearney and Chapman, where most crane use currently occurs. Sites will probably be selected at or near Mormon Island, the Trust's property south of Alda, and the Lillian Annette Rowe Bird Sanctuary.

Table 2. Classification for Platte River surface cover mapping.

Code	Area	Definitions
	River Classes — any class within the outermost banks of the river channels	
CH	ALL	Channel: a polygon indicating the main channels, bank to bank
BB	0.5AC	Beach/Bar: any unvegetated sand bar or gravel/cobble
HE	0.5AC	Herbaceous: includes herbs/woody seedlings under 3 feet tall
SH	0.5AC	Shrubs: any woody vegetation 3 to 12 feet tall
WO	0.5AC	Woody: any woody vegetation over 12 feet tall
	Agricultural/Upland Class — includes 3.5 miles outside of the outer banks	
CO	10AC	Corn: standing corn crops
GS	10AC	Small grain/Sorghum: small grain crops and/or seed sorghum
AL	10AC	Alfalfa: may include both alfalfa and clover
FA	10AC	Fallow: any agricultural area used for growing crops that are presently bare soil
OC	10AC	Other Crops: any crop not specifically dealt with in the above classes that is identifiable
GR	5AC	Grassland: native grass species, many show evidence of
WS	0.5AC	Woods/Shrubs: any tree/shrub stand or row outside the river bank; 30% or woody canopy cover
OW	0.5AC	Open Water: any standing open water outside the river channel
EM	ALL	Emergents: any emergent 'wet grassland' vegetation; emergents 30 feet wide or will be mapped as polygons; emergents 30 feet wide will be mapped as lines (a)
Development Classes — human developments identified as disturbance factors for crane roosting, feeding, and loafing habitats. (b)		
CD	ALL	Commercial Development: any commercial development
UD	ALL	Urban Development: any housing tract
PA	ALL	Paved Road: any publicly maintained paved road
GA	ALL	Gravel Road: any publicly maintained gravel road
PR	ALL	Private Road: any private road considered primary; does not include travel lanes
BR	ALL	Bridge: any bridge across main river channel
PL	ALL	Powerline: any major transmission line
RR	ALL	Railroad: any railroad line
SD	ALL	Single Dwelling: any single dwelling observed
SG	ALL	Sand/Gravel Operation: any active operation

(a) The Grassland and Emergents classes will be evaluated after the photo interpreter has sufficient experience in delineation.

(b) Recreational Sites may be added at a later date.

Staging Area 2, located between Overton and Kearney, will have at least one site, perhaps in a "transitional" or "degraded" river reach (Frith 1976). Staging Area 3, located between Sutherland and North Platte, will also have at least one study area.

We feel the study areas should be allocated among the various staging areas because of both similarities and differences between the respective areas. *Table 3* summarizes selected information supplied by the Platte River Ecology Study (USFWS 1981). Staging

Area 1 is the largest area of consideration and supports the largest number of cranes. Area 2 is larger than Area 3 but supports fewer cranes. Area 3 has a channel of fairly constant width as exemplified by similar means for the widest points and systematically determined widths for each half-mile segment.

Table 4 compares selected in-channel criteria. Mean acres of water for Areas 1 and 2 are similar, but Area 1 supports roughly 5 times as many cranes as Area 2 (*Table 3*). Area 3 has less than half as many acres of water as does Area 2, but supports more cranes. Examination of island characteristics indicates Area 1 is more similar to Area 3 than to Area 2. We feel these similarities and differences between staging areas warrant the selection of study areas in each.

Table 3. Comparison of selected criteria (a) for three areas used for spring staging by sandhill cranes.

	Staging Area		
Criteria	1	2	3
Approximate area (mi^2)	233	99	71
Mean maximum crane use (1980)	264,635	54,697	68,008
Mean density (cranes/mi^2)	1,187	553	958
Mean (b) unobstructed channel width (yd) at widest point	200	152	100
Mean width (yd) of water at midpoint of each half-mile segment	240	225	108
Mean bank to bank width (yd) at midpoint of each half-mile segment	445	683	297

(a) Original data presented in Platte River Ecology Study (USFWS 1981).

(b) Average value obtained from evaluation of each contiguous (east to west) half-mile segment of river within each respective staging area.

Table 4. Comparison of selected in-channel criteria (a) for three areas used for spring staging by sandhill cranes.

	Staging Area		
Criteria	1	2	3
Mean acres of water	42.5	40.6	18.4
Mean (b) acres of islands supporting vegetation: (% of total island acreage)			
2.1 yd	5.2 (13.8)	2.0 (2.4)	4.2 (12.6)
2.2 - 4.3 yd	3.7 (9.8)	3.3 (4.0)	3.3 (10.1)
4.4 yd	28.8 (76.4)	78.0 (93.6)	25.5 (77.2)

(a) Original data presented in Platte River Ecology Study (USFWS 1981).
(b) Average value obtained from evaluation of each contiguous (east to west) half mile segment of river within each respective staging area.

After the selection of respective study areas, existing 1976 photography will be used for analysis. The values for variables identified in the model will be manually determined using a digital planimeter. Model output will then be compared to crane-use information from 1979. Results should be available before the spring 82 phase begins.

Spring '82

During this phase, when cranes are on site, various model assumptions will be evaluated by representatives of the WELUT, and an attempt made to anticipate any future problems in the model or geographic information database. We are particularly interested in evaluating: 1) characteristics of visual barriers, i.e., minimum width required before functional; and 2) minimum size of roost areas. Such investigations can only be conducted while cranes are present on the areas of interest.

We will be in close contact with representatives of the Trust who will advise us as to the best time to conduct these on-site studies. It is anticipated that this phase will occur sometime during the last two weeks of March and/or first week of April.

Postspring '82

The sandhill crane habitat model was built from existing information; therefore, we do not anticipate any major problems with evaluation during the prespring '82 phase. The ultimate "test" of the model, however, will be how well it predicts crane responses to future habitat management activities. The postspring '82 phase of model evaluation will require a long-term committment by the Trust to monitor future habitat alterations and subsequent crane use.

We suggest that the postspring '82 phase be divided into two stages. First, model output from baseline 1982 photography will be compared to 1982 crane census estimates. It is assumed that estimates of crane numbers will be available from the Office of Migratory Bird Management, FWS. However, these estimates will probably only be applicable to a limited time period (period of census). This approach is therefore identical to the prespring 82 phase except that it will utilize the entire 1982 baseline geographic information database. The approach is however of limited utility as a "test" of the model's predictive reliability because it will be operating within the same database from which it was created.

The second stage of model evaluation should begin as soon as the surface cover database has been developed, and the Trust begins habitat management activities. We suggest the Trust approach this stage by using the information base, as directed by the roosting component of the model, to identify segments of the Platte River channel which are wide enough and have appropriate water depth but have vegetative characteristics that are not optimum for good crane roosting habitat. Census information should be consulted to verify a lack of crane use. Once such segments with little or no crane use have been identified, the Trust could perform various habitat manipulation activities on different sites, monitor crane responses, and thus evaluate both model performance and cost effectiveness of different management activities in terms of subsequent crane use. It should be noted that sites supporting crane use, but then altered by management activities directed at enhancement, will probably not yield results suitable for evaluating model performance.

It should be noted that this proposal addresses the involvement of the WELUT through information based development and the first stage of the postspring '82 phase of model evaluation. We suggest that the Trust engage a neutral, unbiased, third party to evaluate the model's performance against crane responses to future management activities (i.e., second state of postspring '82 model evaluation). In some cases, the collection of future crane-use information might be best accomplished by a third party. We feel the use of a respected and unbiased third party would greatly enhance the credibility of future evaluations.

PRODUCTS

This computer automated application of geographic information technologies to sandhill crane habitat assessment along the North Platte and Platte Rivers will provide the Trust with the following products:

- Set of 1982 color infrared aerial photography (1:24,000 scale) purchased by the Trust outside of the budget in this proposal.
- Hardcopy maps of manually photointerpreted surface cover types for the North Platte and Platte Rivers study areas at a 1:24,000 scale (see *Table 5* for listing of USGS quadrangle names).
- Digital computer databases of surface cover types and other data planes as specified by the Trust.
- Composite maps of surface cover types and other data planes as specified by the Trust.
- Data analyses listing surface cover types mapped and showing their respective acreages per study area segment.
- Computer automated sandhill crane habitat suitability model.

Table 5. USGS quadrangles covering the North Platte and Platte Rivers study areas.

North Platte River - Sutherland to North Platte	
1. Sutherland Reservoir NW	3. Hershey East
2. Hershey West	4. North Platte West
Platte River - Overton to Chapman	
1. Overton	9. Prosser
2. Elm Creek West	10. Wood River
3. Elm Creek East	11. Alda
4. Alfalfa Center	12. Doniphan
5. Kearney	13. Grand Island
6. Newark	14. Phillips
7. Gibbon South	15. Chapman
8. Denman	

- Data analyses identifying potential sandhill crane roosting habitat and composite maps showing their location.
- Computer composited maps displaying sandhill crane habitat suitability values per study area segment.
- Capability to evaluate and map for any study area segment the individual habitat requirements for sandhill cranes (e.g., roosting, invertebrate foods and grain foods); identification of limiting factors to sandhill crane habitat suitability.

TECHNOLOGY TRANSFER AND TRAINING

In addition to the specific products which will be provided as a result of this project, the WELUT will provide training to Trust personnel in the use of geographic information system technologies for sandhill crane and other migratory bird habitat assessments. The objective of this technology transfer and training is to make Trust personnel self-sufficient in the use of the Trust's habitat database for data analysis and development of cartographic products.

Training will consist of familiarizing personnel with the operating system and command capabilities of the geographic information system, structuring of data work files, production of map tapes, conducting data analyses, and in-depth knowledge in using the sandhill crane model. Training will initially be conducted at WELUT facilities but can later be conducted at Trust designated facilities, depending on the availability of phone and graphics terminal hardware capabilities. Provision of computer hardware at any site outside of WELUT for training and/or future use by the Trust is the responsibility of the Trust. The WELUT will assist the Trust in defining these needs, in providing cost estimates, and in installing and testing equipment, if requested.

Training is planned to be conducted in two phases (*Table 6*). The first phase will occur during July-September 1982 period after WELUT completion of the digital database for the North Platte study area. The second phase will occur after completion of the digital database for the Platte River study area, initiating about January 1983, and continuing until Trust personnel are confident in the use of the technology.

Table 6. Schedule of critical items required to complete Platte River crane habitat assessment project.

Item	Fiscal year and quarter						
	FY-82				FY-83		
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun
Project proposal	X						
Sandhill crane model evaluation		X	X	X		X	X
Crane model automation		X					
Photo interpretation-North Platte area		X					
Data entry-North Platte			X				
Data analysis-North Platte				X			
Photo acquisition Platte River area				X			
Photo interpretation-Platte River area				X	X		
Data entry-Platte River area					X	X	
Data analysis-Platte River area						X	X
Technology training and transfer				X		X	X

SCHEDULE AND BUDGET

Table 6 lists several critical items required to complete this project, their sequence of occurrence, and relationship to one another. Technology training and transfer is an area which has received only limited discussion with representatives of the Trust. It is an important issue which should be discussed in the near future.

In addition, the FY 82 cost estimate does not include the carryover of funds from FY 81 (see Memo from the WELUT Team Leader to the Trust Exceutive Director dated December 3, 1981). These carryover funds are considered contingency funds for adjustments to the geographic and/or for evaluation of the sandhill crane model, if needed.

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USE OF STAGING AREAS BY SANDHILL CRANES IN THE MIDCONTINENT REGION OF NORTH AMERICA

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ABSTRACT

The midcontinent population of Sandhill Cranes (*Grus canadensis*) in North America interrupts its spring and fall migrations to stop for prolonged periods on staging areas in the central and northern Great Plains. Key features of these sites include shallow water for roosting, high visibility, limited human disturbance, and ample foraging areas. Most roost sites are located either in broad shallow river channels or shallow basin wetlands. Foraging occurs primarily on agricultural lands in the vicinity of the roost. Cereal grains account for a major part of the diet and supply most of the energy requirements. Invertebrates are the dominant food item in native pastures, and supply certain amino acids and calcium that are either deficient or lacking in cereal grains. Staging is accompanied by physiological conditioning of the birds for migration and reproduction. Fat levels of cranes increased from about 8% of body weight in late winter in west Texas to 23% at departure from a staging area in Saskatchewan in late April. Fat is derived primarily from waste corn (*Zea mays*) in Nebraska and wheat (*Triticum aestivum*) in Saskatchewan. Staging habitat of Sandhill Cranes has undergone massive alternation during the past century, primarily due to agricultural development. The status of habitat conditions on staging areas is reviewed and measures proposed to ensure adequate protection for meeting present and future needs of the midcontinent Sandhill Crane population.

The Sandhill Crane (*Grus canadensis*) is perhaps the most abundant member of the family Gruidae. An estimated one-half million Sandhill Cranes currently migrate through the midcontinent region of North America (U.S. Fish and Wildlife Service 1981). The winter distribution of this population extends across parts of the southwestern United States (primarily Texas and New Mexico) and Mexico (Chihuahua). Breeding occurs in central and arctic Canada, Alaska, and in eastern Siberia (Lewis 1977, Walkinshaw 1981). Most Sandhill Cranes in the midcontinent population are of the Canadian (*G. c. rowani*) and Lesser (*G. c. canadensis*) races (Johnson and Stewart 1973, Aldrich 1979, Walkinshaw 1981).

Midcontinent Sandhill Cranes spend 3-4 months of each year in migration (see Melvin and Temple 1982), mostly on staging areas in the Great Plains region of the United States and Canada. A staging area refers to a site where the cranes traditionally stop from several days to a month or longer before initiating the next phase of migration. Traditional stopover sites, as described by Melvin and Temple (1982), are included under the definition of a staging area in this paper. The primary purpose of this paper is to describe various aspects of Sandhill Crane use of staging areas in the midcontinent region.

ABSTRACT

Sandhill Cranes interrupt their spring migration to spend several weeks resting and feeding along the Platte River in Nebraska before continuing on to breeding grounds in central and arctic Canada, Alaska, and eastern Siberia. Some additional time is spent at scattered sites on the Canadian prairies. During fall migration, the cranes gather in Saskatchewan, particularly in the Last Mountain Lake area,

and in central North Dakota. In total, the one-half million cranes of the midcontinent population spend 2-4 months annually at traditional staging areas.

Our studies indicate that sandhill cranes accumulate large fat reserves during the prolonged spring stay in Nebraska. Male and female cranes deposited fat at an average daily rate of 13.2 and 9.1g, respectively. Altogether, an estimated 800-900g of fat are acquired on staging areas in the great plains region during spring. In Nebraska, most of the fat is derived from corn taken from harvested fields. Current harvesting techniques leave about 6-7% of the corn crop in the fields and cattle consume about half during the fall and winter months. Much of the remaining corn is available to cranes when they arrive in late February and March. After departing from Nebraska in early April, the cranes fly on to Saskatchewan where wheat and other cereal grains replace corn as the principal energy source. In late April, the birds depart for their breeding grounds where the fat reserves will be used during reproduction.

Although Sandhill Cranes obtain most of their maintenance energy and fat reserves from agricultural grains while on staging areas, the birds also forage on invertebrates in native pastures and other habitats. These foods serve to balance the diet nutritionally by providing certain amino acids and calcium that are either deficient or lacking in cereal grains. Diurnal habitat use patterns in Nebraska reflect the cranes' attempts to meet their varied needs by utilizing several habitat types. The principal habitats used during daylight hours, based on monitoring of radio tagged birds, are cropland (55%), cattle pastures (27%), and hayland (15%). Time budget observations indicate about one-third to one-half of the daylight hours are spent foraging. In Nebraska, cranes feeding in cropland take corn almost exclusively whereas birds in native meadows feed principally on invertebrates.

Cranes select roosting sites with good visibility and limited human disturbance. In the Platte River Valley, nocturnal roosting by cranes occurs principally in the shallows and on sandbars in the river channel. Cranes prefer roosting in areas where the channel is at least 150m wide, and avoid channels narrower than 50m. Cranes on staging areas in Saskatchewan and North Dakota roost primarily in shallow basin wetlands, particularly saline sloughs with limited emergent vegetation. Land ownership patterns, land use, and protection from hunting have contributed to the massive buildup of cranes along the Platte River in spring by providing ample food supply and by limiting human disturbance. Habitat preservation measures recommended for meeting the requirements of Sandhill Cranes on staging areas in the great plains region are described.

DISTRIBUTION OF STAGING AREAS

The best known staging areas of the midcontinent population are along the Platte and North Platte rivers of Nebraska (*Fig. 1*), where nearly the entire population gathers during March of each year (Krapu et al. 1982). About 400,000 cranes occur along a 115km reach of river between Overton and Grand Island; most of the remaining cranes in the population gather about 100km upstream along the North Platte River. During their northward migration from the Platte, some cranes stop temporarily in North Dakota and northeastern Montana (Walkinshaw 1949:119). Upon reaching Saskatchewan, the primary flight corridor extends through the Last Mountain Lake-Quill lakes area of central Saskatchewan (Munro 1950). The length of stay on the Canadian prairies in spring is relatively short in comparison to time spent there in fall.

During fall migration, Sandhill Cranes are widely distributed in groups of various sizes in the north central United States and Canadian provinces of Manitoba, Saskatchewan and Alberta (*Fig. 1*). In the Kindersley District of Saskatchewan, peak populations o 50,000 cranes have been reported (Buller 1967) with populations of 25,000 each along the South Saskatchewan River and Last Mountain Lake-Quill lakes area. In central North Dakota, the primary staging areas are in McLean, Pierce, and Kidder counties (Johnson and Stewart 1972). A maximum fall population of 15,800 cranes has been reported at Lake Williams, an alkaline lake in McLean County (U.S. Department of the Interior, Bureau of Reclamation 1980:67), and 34,000 cranes were observed in mid-October 1979 in Kidde County and adjoining areas of Stutsman County (Melvin and Temple, 1983). A peak fall population of 12,000-18,000 cranes has been reported for the Mobridge-Pollock area o north central South Dakota and 10,000 cranes have been sighted at Medicine Lake Montana (Buller 1967). Other significant staging areas during fall migration include

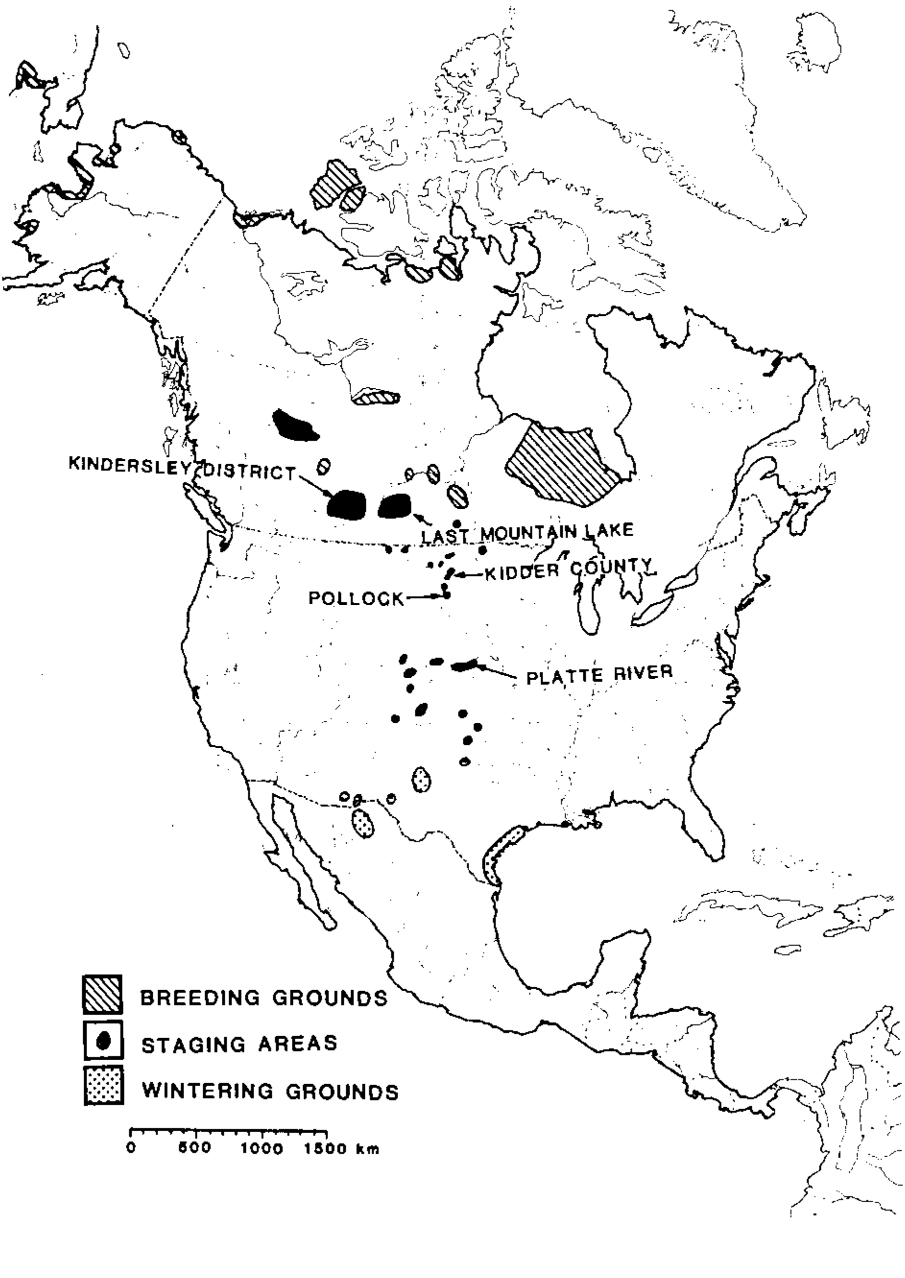

Fig. 1. Major staging areas used by the midcontinent population of Sandhill Cranes in North America. Key breeding and wintering grounds are also shown (after Lewis 1977).

Prewitt Reservoir in Colorado and the Wachita National Wildlife Refuge (NWR) and the Salt Plains NWR in Oklahoma (Buller 1967). Smaller numbers of Sandhill Cranes occur at widely scattered sites in the north central United States and adjoining prairie provinces of Canada.

CHRONOLOGY OF USE

Spring

Sandhill Cranes wintering in west Texas begin migrating to the Platte River in late February and early March (Iverson 1981:8). The population gradually builds on the Nebraska staging areas and reaches a peak near the end of the third week of March. Departure usually occurs by the end of the first week of April. During years when weather conditions are adverse, however, most of the cranes may remain an additional week or more. After brief stops in the Dakotas and Montana, most cranes move to isolated sites in the Canadian prairie region and depart from there for nesting grounds during late April and May. The initial arrival of *G. c. canadensis* at major breeding grounds on the Yukon-Kuskokwim Delta in Western Alaska occurs in early May (Boise 1977). Lumsden (1971) observed the first arrivals of *G. c. rowani* in the James Bay breeding area on 21 April 1968 and 25 April 1969.

Fall

Cranes return to the prairies from their breeding grounds beginning in mid-July (Buller 1967). Arrival dates vary among areas, in part, because several subpopulations from widely separated breeding areas are involved. Migrant cranes disperse widely across the Canadian prairie provinces in autumn. The first arrivals reached prairie staging areas in Alberta, Saskatchewan, and Manitoba between early August and mid-September (Buller 1967). Many of the early arriving cranes are *G. c. rowani*, which breed in Alberta, Saskatchewan, west central Manitoba, and the southern Mackenzie District of the Northwest Territories (Walkinshaw 1965). These birds nest relatively close to their fall staging areas. In North Dakota, *G. c. rowani* begin appearing at alkaline lakes in Kidder County in August (Johnson and Stewart 1973), but large numbers are usually not present until mid-September; peak concentrations occur in mid-October (Melvin and Temple, 1983).

The Lesser Sandhill Crane breeds in arctic regions and generally arrives later on the prairies than do *G. c. rowani*. Dement'ev and Gladkov (1967) noted that at Anadyr Bay in Anadyr Territory of eastern Siberia, departure dates for *G. c. canadensis* in 1930 were between 29 August and 13 September. Peak numbers of *G. c. canadensis* on the McLean County, North Dakota, staging area were observed from 5 to 11 October in 1979 when about 21,000 cranes were present (U.S. Department of the Interior, Bureau of Reclamation 1980). At a staging area near Pollock, South Dakota, *G. c. canadensis* arrive about 10 September each year (Buller 1967). At Last Mountain Lake, in central Saskatchewan, where both *G. c. canadensis* and *G. c. rowani* gather, the number of cranes increases rapidly during August, reaching a peak population by late September (Stephen 1967). Following departure from the northern prairie region in October and early November, the birds move southward toward the wintering grounds. Some cranes stop in Colorado and Oklahoma while enroute to wintering areas. In contrast to spring, few migrant cranes stop in Nebraska during fall.

HABITAT SELECTION

Key characteristics of staging areas used by Sandhill Cranes in the midcontinent region include (1) shallow water areas that afford a high degree of visibility and suitable substrates for roosting at some distance from shore, (2) the presence of ample foraging habitat nearby, and (3) low levels of human disturbance.

Roost Sites

Typical roost sites are in broad, shallow river channels (Lewis 1976, Krapu et al. 1982) and basin wetlands (Munro 1950, Stephen 1967, Johnson 1976, Soine 1982). Major rivers that are still used to varying degrees include the Platte, North Platte, Red, Missouri, and South Saskatchewan.

In the Dakotas and south central Canada, most roosts are situated in basin wetlands. Alkaline lakes are the most used wetland type (see Stewart and Kantrud 1971 for description); the sites usually are shallow and largely devoid of emergent vegetation. These conditions allow cranes to roost in water at some distance from shore, secure from approaching mammalian predators. Fen areas that are often present along the shore of alkaline wetlands, or man-made dugouts for livestock watering, provide drinking sites (Johnson and Stewart 1972, Johnson 1976).

Midcontinent Sandhill Cranes are intolerant of tall vegetation near roost sites. In research conducted along the Platte and North Platte rivers, nearly 70% of all roosting cranes were located in river segments having an unobstructed channel width of at least 150m, and 99% were in channels over 50m wide, although unobstructed channel width exceeded 50m in only about 25% of the river segments (Krapu et al., 1984). The relationship between crane usage, channel width, and height of adjacent vegetation along the Platte River is shown in *Fig. 2.* Beyond an unobstructed channel width of 150m, vegetation height along shore does not appear to influence channel usage.

Sandhill Cranes are more opportunistic when selecting nontraditional stopover sites. Studies have shown that migrant cranes, when stopping overnight during flights between traditional staging areas, utilize stock ponds and wetlands of various sizes and types (Melvin and Temple 1982), and occasionally dry land (Lewis 1976). During early spring in North Dakota, flooded stubble and fallow cropland serve as roost sites when wetlands are often still covered with ice (U.S. Department of the Interior, Bureau of Reclamation 1980). Flooded meadows in the Platte River Valley are often used as roost sites in early spring when suitable riverine sites are not available.

Foraging Sites

While on staging areas, Sandhill Cranes forage primarily on agricultural lands in the vicinity of roosts. Feeding occurs between dawn and dusk. Along the Platte River in spring, 90% of the areas used by radio tagged cranes were within 4.5km on either side of the channel (G.L. Krapu, unpubl. data). Limited human disturbance and an abundance of food in close proximity to the channel are primary factors causing cranes to forage near their roost sites. Radio tagged cranes monitored during fall in North Dakota spent 86% of their time within 6.4km of the night roost (Melvin and Temple 1983). Movements up to 17.7km were recorded when hunting affected daily activities. When not subjected to hunting, cranes at Last Mountain Lake in Saskatchewan during autumn are usually not seen more than 3.2km from water (Munro 1950).

Diurnal patterns of habitat use are influenced by several factors including nutritional requirements of the cranes, visibility, levels of human activity in the vicinity, and availability of drinking water. During spring in Nebraska, radio tagged cranes spent an average 55% of the daytime in cropland, 27% in native grassland, and 15% in tame hayland (Krapu et al., 1984). Ninety-nine percent of the cropland locations were in cornfields, 94% of the grassland locations were in grazed pastures, and most of the tame hayland usage was in mowed alfalfa fields.

In general, patterns of habitat use by Sandhill Cranes in North Dakota and Saskatchewan in fall were similar to patterns observed in Nebraska during spring. Each morning at about dawn, the birds fly from roosts to feeding sites, usually in cultivated fields of cereal grains (Stephen 1967, Melvin and Temple 1983). Hayfields, pastures, and idle grasslands also serve as feeding areas but are most commonly used for loafing, especially from midmorning through late afternoon. During midday, cranes in North Dakota typically seek areas with fresh water available such as fens or dugouts. In spring at

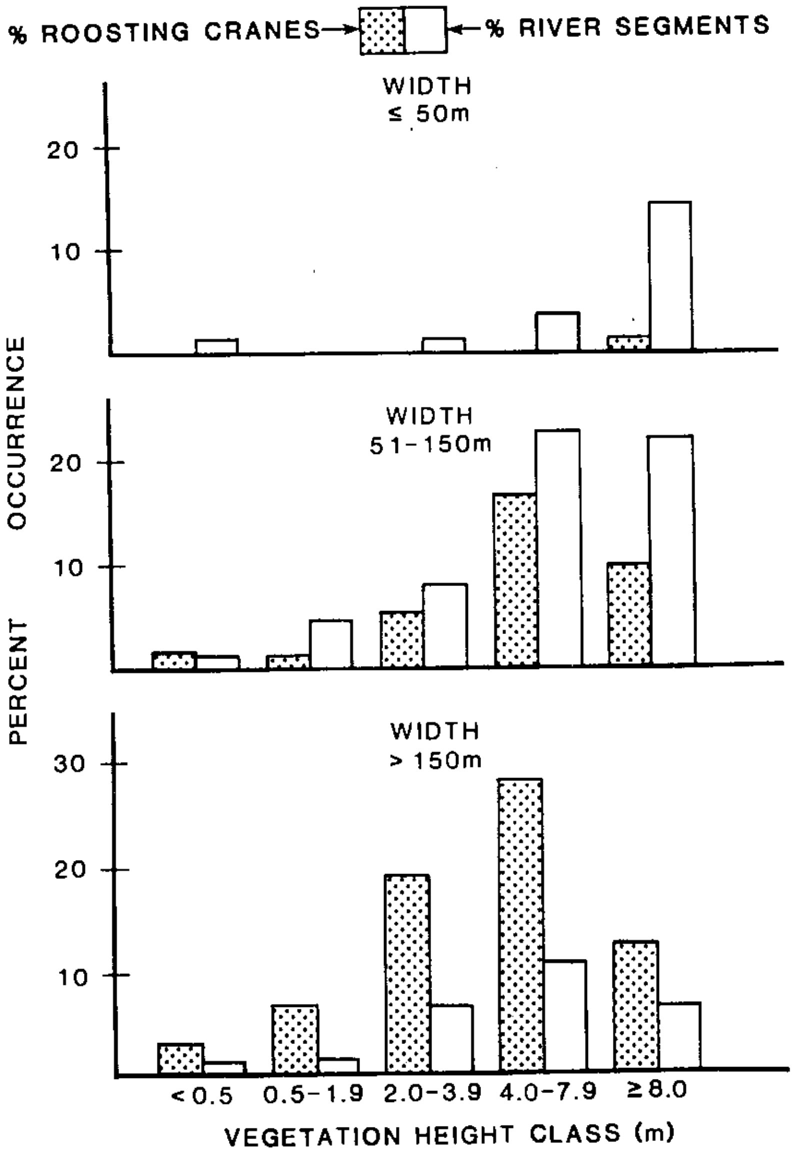

Fig. 2. The distribution of roosting Sandhill Cranes along the Platte River in Nebraska in relation to channel width and height of woody vegetation along the shorelines.

Last Mountain Lake, Saskatchewan, many cranes were observed returning to wetlands during midday, but by early afternoon they were back in fields (Stephen 1967).

Frequent use of cropland by cranes during migration stems from availability there of foods well suited for meeting energy requirements. Cranes feed almost exclusively on cereal grains while foraging on cropland in the Great Plains region (Madsen 1967, Stephen 1967, Reinecke and Krapu 1979). Nearly all of the food taken in spring is waste grain remaining in the fields after harvesting operations (Reinecke and Krapu 1979). Studies in Nebraska indicated that an average of 128kg/ha of shelled corn remain available to the cranes after livestock have grazed the fields during the fall and winter months (K.J. Reinecke, unpubl. data). In excess of 90% of the cranes' energy requirements while at the Platte come from corn.

Cereal grains became a dietary staple of migrant cranes soon after the advent of agriculture in the midcontinent region. In Utah, Dr. H.C. Yarrow noted in 1872, "It [the Sandhill Crane] is fond of frequenting the old stubble fields in the vicinity of the settlements" (Sugden 1938). Cranes were feeding in cornfields in Montana in 1898 (Cameron 1907) and their affinity for corn in Minnesota in the early settlement period hastened their demise because hunters would construct hollowed out blinds in corn shocks to shoot them effectively (Roberts 1932). The preference of cranes for cereal grains has led to depredations on unharvested grains in some areas during early fall, particularly on the Canadian prairies (Stephen 1967).

In grassland and hayland, invertebrates dominate the diet. Earthworms, beetles, grasshoppers, cutworms, and snails were the principal foods taken in native pastures of the Platte River Valley (Reinecke & Krapu 1979). A composite diet of all food consumed consisted of about 96% corn and 4% animal matter. The small proportion of invertebrates in the overall diet, however, probably underestimates their importance in meeting nutrient requirements. Foraging by cranes in meadows and hayfields to obtain invertebrates helps balance the diet nutritionally by adding certain amino acids and calcium that are lacking or deficient in corn.

Feeding at Last Mountain Lake during fall occurs in grainfields, fallow land, and pastures (Munro 1950). Grain was present in 93% of 190 gullets reported by Stephen (1967), based on sampling of cranes as they passed from fields to roost sites. Wheat was the principal food source; barley (*Hordeum vulgare*) was present in six samples and oats (*Avena sativa*) in one. Only one bird contained insects, probably a reflection that birds were collected after they had been feeding in cropland.

STAGING AREAS AS CONDITIONING SITES

Staging areas serve as important conditioning sites for preparing birds for migration and reproduction. Both male and female Sandhill Cranes undergo a marked increase in body weight during spring and fall migrations across the Great Plains. Most of the increase in body weight is the result of fat deposition. Carcass fat content of adult *G. c. canadensis* increased from about 8% of body weight at departure from the wintering grounds in west Texas in mid-February to 23% at departure from staging grounds in central Saskatchewan in late April (Krapu et al., in prep.).

The Platte River Valley serves as an important fat deposition site during spring migration (*Fig. 3*). Adult male and female *G. c. rowani* deposited fat while in the Valley at a daily rate of 13.2 and 9.1g, respectively. Assuming a 30 day stopover interval, adult males and females deposit an average of about 400 and 275g, respectively. Additional fat deposition occurs northward in the prairie region as the birds continue their spring migration. During autumn, staging areas also serve as fat deposition sites (G.L. Krapu, unpubl. data).

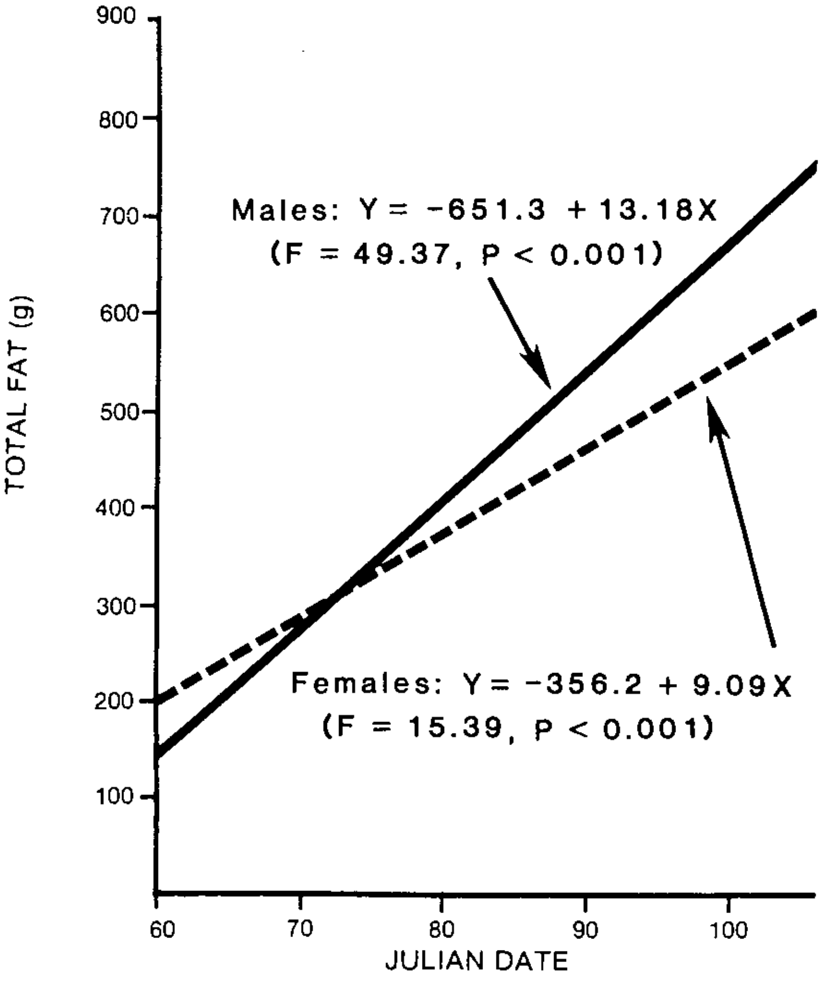

Fig. 3. The ratio of fat to fat-free dry weight (FFDW) by julian date for sampled adult male and female *G. c. rowani* during the spring staging period in Nebraska.

EFFECTS OF HABITAT ALTERATION ON STAGING

Agriculture and other forms of human activity, beginning in the 1870-1910 period and continuing to the present, have markedly altered use of staging sites by Sandhill Cranes. Abundant new food sources associated with agricultural development in the midcontinent region have caused changes in crane distribution. Waste grain left by mechanical harvesting equipment provides an abundant and widespread source of high energy foods. These conditions have allowed much higher densities of cranes to occupy remaining staging areas than previously was possible. This situation has caused massive changes in the distribution of cranes during migration in the Great Plains region. The Platte River staging area, with extensive high quality roosting and foraging habitat still available, has probably absorbed the function of numerous staging areas that formerly existed in the central and northern Great Plains region. Investigations of Common Cranes (*G. grus*) at the Laguna de Gallocanta in north central Spain indicate a pattern of marked growth in use of that site as a staging-wintering area (Alonso et al., this volume), apparently for some of the same reasons responsible for the buildup of Sandhill Cranes along the Platte River. These investigators attributed the buildup to the presence of suitable roosting habitat, restricted hunting, and the recent mechanization and intensive cultivation on surrounding lands, creating an abundant and continuous food source.

Various forms of development are responsible for a major reduction in suitable staging habitat for Sandhill Cranes. In modern times, efforts to divert, for irrigation, flows that previously had maintained crane roosting habitat have been widespread, particularly in central and southern parts of the cranes' midcontinent flyway. Patterns of habitat loss along the Platte River reflect the vulnerability of crane roosting sites to water developments. With a 70% decline in average annual flows during the past century and an associated reduction in the channel's scouring capacity (Kroonemeyer 1979), the width of the channel of the Platte River had been reduced by 80-90% along major reaches during the 1865-1965 period (Williams 1978). Thousands of hectars in channel have become decidious woodland and are no longer suitable roosting habitat. As a consequence, cranes have abandoned about two-thirds of the channel habitat formerly available to them along the Platte, leading to the high densities now observed along the 111km of river still usable to the cranes (Krapu et al. 1982).

Water development has also adversely impacted certain other staging areas in the midcontinent region. In Oklahoma, cranes no longer use the South Fork of the Red River, a river depleted by diversions, because salt cedar (*Tamarix gallica*) encroached upon the channel (Lewis 1976). Staging habitat in South Dakota was lost in the 1960s when Oahe Reservoir was filled as part of the Pick-Sloan Plan for flood control and irrigation in the Missouri River Basin (Johnson 1963). In North Dakota, no major staging areas have been lost in recent times, but plans have been proposed to deepen and freshen certain alkaline lakes heavily used by cranes as a means to improve the lakes' recreational potential. Plans to freshen Lake Williams, a major Sandhill Crane staging site, have been modified, taking into consideration the needs of cranes (U.S. Department of the Interior, Bureau of Reclamation 1979).

As a result of passage of the National Environmental Policy Act of 1969 (P.L. 91-190), habitat requirements of migratory birds in the United States are now given more attention during project planning activities than formerly. The Act provides for a detailed assessment of environmental impacts of proposed federally funded projects in advance of construction. This legislation has proved to be useful as a means to identify problems early so that changes can be incorporated at the planning stage and thereby reduce habitat loss to Sandhill Cranes and other wildlife.

HABITAT PRESERVATION AND MANAGEMENT

Sandhill Cranes use both public and private lands during spring and fall migration in the midcontinent region. Several national wildlife refuges along their flight corridor receive use, particularly during the fall migration. Cranes began using some refuges in the midcontinent region soon after these areas were set aside for wildlife during the 1930's and 1940's. The LaCreek NWR in South Dakota, Crescent Lake NWR in Nebraska, Lostwood NWR in North Dakota, and Muleshoe Lake NWR in Texas were receiving significant use by cranes in 1943 (American Ornithologists' Union 1944). Several refuges in the midcontinent region continue to be important staging sites. Sandhill Cranes also use private lands extensively. Along the Platte River, for example, there are no national wildlife refuges or state owned areas, and only one publicly owned area is managed for

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N INTEGRATED APPROACH TO CRANE RESEARCH - LESSONS FROM SANDHILL CRANES OF MID-CONTINENTAL NORTH AMERICA

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ABSTRACT

Sandhill Cranes (*Grus canadensis*) inhabiting midcontinental North America breed in Siberia, Alaska, and Canada and migrate to wintering areas in Texas, New Mexico, and Mexico. The require international cooperation in research and management. Integrated research is needed to depict adequately and integrate the basic biology of a species and to execute proper management. Parameters investigated to assess population trends should include estimation of population size, age and sex distributions, age-specific recruitment, and age-specific mortality. In addition, detailed knowledge of migration routes and seasonal distribution patterns, habitat use and feeding ecology, behavioral repertiore and time budgets, energetics, diseases and parasites, and social organization throughout the annual cycle will allow early detection of real or potential problem areas for management consideration. Real and potential problems of mid-continent Sandhill Cranes were identified and provide insight into research and management associated with other species of cranes.

Our purpose is to discuss an approach to integrated crane research developed as a result of our experience with Sandhill Cranes from midcontinental North America. Integrated research refers to concurrent investigations of the more important interacting environmental forces that influence a species, population, community, or system. For example, a detailed listing of the foods consumed by a species has greater application if we have detailed data on habitat use and the physical and behavioral adaptations a species utilizes to gather its food. Adequate management and conservation efforts require knowledge of the myriad of interdependent relationships between individuals of a species and their environments, and between individuals within the species. Integrated (holistic) research provides the opportunity for each additional study component to aid our understanding of the basic biology of the species, and results of a number of integrated concurrent studies provide more useful data than a series of related but unintegrated studies conducted at different times or places.

ABSTRACT

Integrated research is needed to adequately understand the basic biology of a species and to execute optimum management. Research should include estimation of population size, age and sex distributions, recruitment, and mortality to assess population trends. Migration routes and seasonal distribution patterns, habitat use and feeding ecology, a behavioral repertiore and time budgets, energetics, diseases and parasites, and social organization should be studied throughout the annual

cycle in order to identify problem areas for management consideration. Failure to execute an integrated research program could result in an inability to identify real or potential problem areas. Understanding of the biology of endangered cranes will probably be limited by lack of information from carcasses. The ability to mark and monitor movements of the species of interest is critical to several phases of an integrated research program. Real and potential problems of midcontinent sandhill cranes were identified and may provide insight into problems associated with other species of cranes.

METHODS

Investigations into the basic biology of midcontinent Sandhill Cranes are limited by our ability to identify ages, sexes, subspecies, social classes, and other important species groups. Development of research techniques to identify age and sex classes is fundamental to a comprehensive integrated research effort.

Our ability to manage a species is generally limited by our knowledge of population status and environmental requirements of a species. Determination of population status usually requires estimation of parameters such as population size, age ratios, and sex ratios. Determination of environmental requirements requires an understanding of behavior and physiological factors that are complex and interrelated.

To discuss an integrated approach to research, we identified a series of study components and divided them into 3 rather arbitrary groups. The groups include research techniques, population studies, and behavior physiology studies (*Fig. 1*). Research techniques useful for Sandhill Crane studies are located at the periphery of *Fig. 1* and interact directly with and perhaps limit several other components. The upper complex of study components (*Fig. 1*) reflects the important population studies. The lower complex indicated integration of important behavior and physiology studies. We arbitrarily divided the annual cycle into nesting, and migration and wintering periods. We did not conduct studies during the nesting period due to logistic, funding, and personnel limitations, but appropriate study components would be similar to those conducted during the winter and migration periods (center-right of *Fig. 1*)

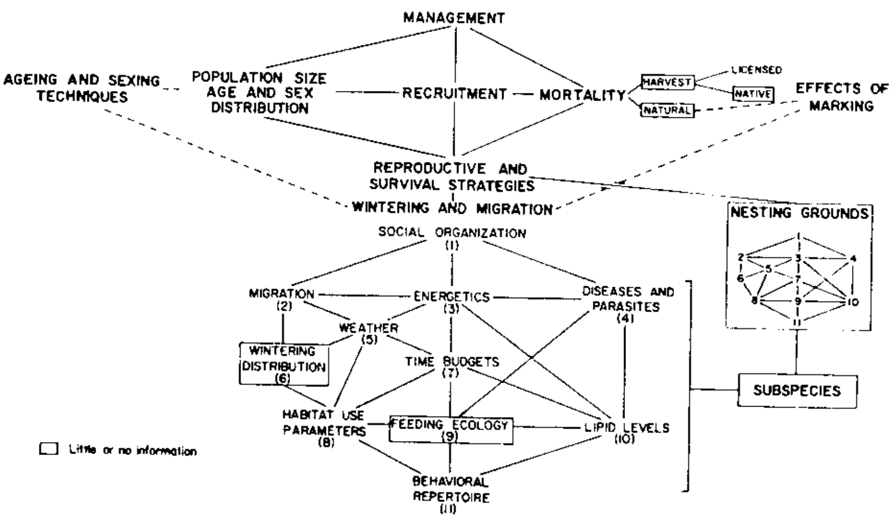

Fig. 1. Study components and relationships of research on Sandhill Cranes from midcontinental North America conducted by the Oklahoma Cooperative Wildlife Research Unit.

RESEARCH TECHNIQUES

Cranes exhibit external monomorphism and are difficult research subjects. Problems in identification of ages, sexes, social classes, and subspecies of Sandhill Cranes provide examples of the difficulty of developing crane research techniques.

Lewis (1979) and Tacha and Vohs (1984) have established methods for field identification of juvenile Sandhill Cranes from time of hatching until 9 months of age. However, no reliable method for grouping individuals into older age classes has been developed, other than the time consuming and expensive practice of marking and following known-age birds. The sex of Sandhill Cranes can be determined by gonadal examination, but at great risk to live birds in the field. Sex can be determined for about 20% of adults by cloacal examination (Tacha and Lewis 1979). Sex of a few paired adults can be distinguished by observation of the unison call (Archibald 1976). Adult female Sandhill Cranes are smaller than adult males, but size differences between sexes are confounded with size differences in subspecies (Johnson & Stewart 1973, Tacha 1981). Studying the external morphology of different age classes of captive cranes could provide needed field methods for ageing and sexing the birds.

Tacha (1981) was able to classify juveniles into 2 social groups based on behavioral observations of marked birds. After careful behavior observations of marked cranes, techniques were developed that allowed some unmarked adults to be assigned to social groups of unpaired, paired, or parents. Studying behavior of individually identifiable marked birds of other species could eventually provide methods for delineating social status of unmarked cranes.

Tacha (1981) found reasons to question seriously the utility of currently accepted methods for classification of individual midcontinent Sandhill Cranes into subspecies. However, subspecies are difined to constitute a group of birds that inhabit an identifiable subdivision of the breeding range of a species, and the ability to identify individuals into subspecies could provide a method of identifying manageable subpopulations of some crane species. Analysis of morphological measurements of cranes systematically collected from across the breeding range could identify the presence of isolated subpopulations (or subspecies).

Observations of individually marked wild cranes can be used to develop techniques to identify social classes, to establish the important parameter of age of first breeding, and to facilitate behavioral and other studies. Marking necessitates both capture and marking with neck collars, patagial streamers or other agents. Marking Sandhill Cranes with patagial streamers caused abnormal behavior (Tacha 1979). Use of rocket nets to capture Sandhill Cranes in western Texas resulted in 10-15% mortality (Tacha et al. 1982). The effects of capture and marking must be considered carefully when performing research on endangered cranes. However, some important data can only be obtained through marking.

POPULATION STUDIES

A number of fundamental questions regarding population characteristics need answering before effective crane management can be implemented. Is there more than one population to consider (are there true subspecies)? If so, we need answers to questions about each population. How many cranes are there in the population? What is the age distribution? The sex distribution? How many cranes (or what proportion of the population) are recruited to the breeding population each year? How many (what proportion) die? Do mortality and recruitment offset each other? All of these are fundamental to the central question: is the population increasing, static, or decreasing, and why? Sandhill Cranes provide an example of the value of and need for multifaceted and integrated population studies.

Prior to 1980, for example, scientists estimated only 250,000-300,000 midcontinent cranes. Our more recent studies on the wintering areas indicated at least 550,000 birds, and about 11% recruitment to 1 year of age. Based on our population estimates, approximately 4-5% of midcontinent cranes are harvested (sport and native) each year, but we don't know natural mortality rates. Despite progress in estimating population parameters, we still are unable to determine with certainty if midcontinent Sandhill Crane populations are increasing or decreasing.

Optimum sex ratios are 50:50 among breeding adults of a monogamous species such as the Sandhill Crane. Our field investigations showed only 45% males among adult Sandhill Cranes, but males made up 55% of the harvest. The significance of this disparity is unknown and requires further investigation.

Little information is available on basic population parameters for most species of cranes. Scientists have studied midcontinent Sandhill Cranes for years, but still cannot identify population trends. Determining with precision the status and trends of poulations for all species of cranes should be a research priority.

BEHAVIOR-PHYSIOLOGY STUDIES

The behavior-physiology complex of study components is located under "wintering and migration" in Fig. 1. These studies can provide information of direct management value through better understanding of the factors determining the physiological condition of the cranes, and factors responsible for population trends. Results of these studies can also identify required habitats that may be preserved, improved, or created through management.

Studies of habitat use and availability provide data on environmental requirements of a species. Johnson (1980) suggested that these habitat use studies be conducted at the continental, regional, and local levels. For example, we conducted migration (continental), wintering distribution (regional), and local wintering habitat use studies (*Fig. 1*). Results from these concurrent studies provided insights into real and potential habitat values and problems for midcontinent Sandhill Cranes throughout the wintering and spring migration periods.

Migration studies based on observations of marked birds indicated 2 relatively discrete fall migration corridors that were associated with 2 identifiable wintering areas. One subpopulation of 500,000 Sandhill Cranes winters in the western Texas area, and another subpopulation of about 60,000 cranes winters on the Texas Gulf Coast. Other species of cranes, such as the Siberian Crane (*Bugeranus leucogeranus*) have similarly identifiable subpopulations.

Winter distribution studies revealed the size (500,000+) of the western subpopulation. Cranes become extremely concentrated (as much as 60% of the subpopulation on 1 roost site) just prior to northward migration. This led to an intuitive concern about disease transmission, and also provided an opportunity to count the population. Observations indicated no large losses of cranes to disease, and surveys of blood antibodies to 3 avian diseases found no widespread diseases in the population. Examination of carcasses for helminth parasites revealed a high frequency of occurrence of parasites, but few cranes with heavy infestations were found (Iverson et al. 1983). Habitat use studies at 4 locations indicated that cranes used small grain fields in much higher proportion than availability throughout the wintering and spring migration periods. Time budgets documented feeding in small grain fields and studies of food habits of Sandhill Cranes verified that small grains constituted over 90% of the diet during wintering and spring migration periods (Iverson et al. 1982).

Planned concurrent behavior and physiology studies can provide a wealth of information about interactions between cranes and their environment, and allow determination of where and under what circumstances environments fail to meet the biological requirements of the birds. A behavioral repertoire was developed for Sandbill Cranes tbat provided a basis for time budgets during winter and spring. Continuous recording of behaviors for 20 minute periods allowed quantitative estimates of time cranes spent in different habitats and allowed comparison between different locations. Concurrent studies of lipid levels provided estimates of the physiological condition of cranes. Calculations from time budgets suggested high energy expenditures in Texas on the wintering grounds and in Alaska just prior to nesting, and lowest energy expenditures at a major spring staging area in the Platte River Valley of Nebraska. Studies of lipid levels documented maintenance or loss of fat during winter, deposition of fat in Nebraska, and maintenance of fat during the remainder of spring migration (Iverson 1981, Krapu et al. in prep). These concurrent studies showed that small grain fields in western Texas barely provided enough food in some years, and that staging in the Platte River Valley provided an important opportunity for cranes to store fat for transport to the nesting grounds.

Analysis of sightings of color marked birds (from migration studies) and time budgets (from behavior studies) allowed us to highlight the Platte River Valley as the primary location where midcontinent Sandhill Cranes form pair bonds. The activities leading to pair formation were highly associated with hayfields within 0.8km of the Platte River.

Integration of results from 3 different study components allowed identification of the Platte River Valley of Nebraska as an important source of energy, and as an area where pair bonds were formed.

Integration of concurrent studies had added value in describing social organization of Sandhill Cranes. Sightings of individually marked cranes to date provide no evidence of pair formation until midcontinent Sandhill Cranes reach 4½ years of age. Concurrent time budgets and sightings of marked cranes were needed to document that at least 90% of juveniles remained in family units until April following the hatching year, that large wintering flocks were unstable with few social bonds other than pairs or family units, and that the tendency to aggregate declined rapidly among adult cranes as spring migration progressed.

A HOLISTIC APPROACH

Concurrently executing a number of studies profoundly increased our ability to interpret results. Integration of data sets either reinforced or caused us to question our conclusions, and allowed development of additional hypothesis. The relationship between cranes and their environments is complex and interdependent. Integrated concurrent studies can help to unravel these relationships, to protect against biased conclusions drawn upon only a single aspect of the relationships, and extend limited financial resources. An integrated approach requires coordinated and cooperative team work. Both quantity and quality of work can be improved with additional qualified personnel that are willing to share effort and information. The holistic approach requires careful planning prior to study initiation, open communication between investigators, and attention to detail in the scientific method. International and/or interagency cooperation can assist the financing and planning for holistic studies that provide adequate manpower, coordination, and financing to maximize cost benefits.

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STATUS AND DISTRIBUTION OF CRANES IN NORTH AMERICA

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ABSTRACT

The sandhill crane (*Grus canadensis*) and endangered whooping crane (*G. americana*) are the only cranes native to North America. The whooping crane reached a population low of 21 in 1941 but now numbers about 85 wild and 29 in captivity. This bird is symbolic of efforts to conserve endangered species in North America. The only self-sustaining whooping crane population winters at Aransas National Wildlife Refuge and vicinity on the Texas Gulf Coast and nests in Wood Buffalo National Park, Northwest Territories, Canada. A unique restoration experiment is underway to establish a second wild population that will nest at Grays Lake National Refuge in Idaho and winter in New Mexico. There are 6 sandhill crane subspecies; 3 are migratory. Nonmigratory subspecies are the Cuban sandhill (*G. c. nesiotes*) which is believed to number about 200 living in western Cuba and on the Isle of Pines, the estimated 6,000 Florida sandhill (*G. c. pratensis*) of Florida and southern Georgia, and the 40-50 Mississippi sandhills (*G. c. pulla*) of Jackson County, Mississippi. An estimated 40,000 to 45,000 greater sandhill cranes (*G. c. tabida*) nest in the northern United States and Canada and winter in the southern United States. The Canadian sandhill crane (*G. c. rowani*) nests in central Canada, and winters in Texas, New Mexico, Arizona, and Mexico. The lesser sandhill (*G. c. canadensis*) crane nests in Siberia, Alaska, and northern Canada and winters in Texas, Oklahoma, New Mexico, California, and Mexico. Virtually all lesser and Canadian races in North America, except for 25,000 lessers that winter in California, congregate each spring in the Platte River Valley, Nebraska. Counts in 1980 by the U.S. Fish & Wildlife Service indicated about 540,000 cranes on the Platte River. The lesser and Canadian races are hunted in parts of North America and the annual harvest is about 20,000 birds.

WHOOPING CRANE

The whooping crane is the tallest North American bird; males are about 1.5m when standing erect and exceed the greater sandhill in height by 0.1 to 0.2m. Males are generally larger than females, and weights of adult birds in captivity have averaged 7.3kg for males and 6.4kg for females. Plumage of the adult is snowy white except for black primaries, black or grayish alulae, sparse black bristelike feathers on the carmine crown and malar region, and a dark gray-black, wedge-shaped patch on the nape.

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. A separate, nonmigratory breeding population also occurred in southwestern Louisiana. The whooping crane disappeared from the heart of its breeding range in 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 was discovered in 1954 in Wood Buffalo National Park, Canada. This latter population is the only one that still exists.

The present nesting area within Wood Buffalo National Park lies between the headwaters of the Nyarling, Sass, Klewi, and Little Buffalo Rivers (Kuyt 1981). The terrain is characterized by oxbowed rivers and streams, with numerous ponds separated by low, narrow ridges. Bulrush (*Scirpus* sp.) and sedges (*Carex* spp.) are the dominant emergent plants in ponds occupied by nesting pairs and are used in nest construction. Due to the low topographic relief, water levels are substantially dependent on rainfall. Nesting ponds average 25cm in depth. Established pairs show considerable fidelity to their breeding territories which have a radius of 0.9-1.0km and encompass 3.0-3.8km^2 (Kuyt 1976a, b). The Wood Buffalo population winters on Aransas Wildlife Refuge and bordering areas on the Texas Gulf Coast.

Pairs and family groups occupy and defend relatively discrete winter territories, although close association is tolerated at times. These territories average 176ha (60-400ha) 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 cunata, Cyrtopleura costada, Phacoides pectinata,* and *Macoma constricta*) — predominate in the winter diet (Allen 1952, 1956; Uhler and Locke 1970; Blankinship 1976). Most foraging occurs in brackish bays, marshes, and salt flats lying between the mainland and barrier islands.

The average minimum age of breeding in the wild is unknown, but individuals are thought to attain sexual maturity when 4 to 6 years old. These cranes are monogamous and have lifelong pair bonds. Whooping cranes normally lay 2 eggs. The factors that limit chick and juvenile survival are poorly known but only about 1 of every 4 hatched chicks reaches the wintering grounds. Habitat alteration and hunting presumably were the main factors that caused the population decline and low productivity has prevented quick recovery.

Whooping cranes in captivity

In June 1982, 30 whooping cranes were in captivity including (1) 26 at Patuxent Wildlife Research Center, Maryland, (2) 2 at the San Antonio Zoo, Texas, and (3) 2 at the International Crane Foundation, Baraboo, Wisconsin.

The principal goals of maintaining a captive flock of whooping cranes at Patuxent Research Center are (a) to foster basic research on the species, (b) to preclude extinction of the species if there is some catastrophic loss to the wild population, and (c) to produce birds for release into the wild (Erickson and Derrickson 1981). The captive flock maintained at Patuxent is a cooperative endeavor involving the U.S. Fish & Wildlife Service and Canadian Wildlife Service (they provided eggs which formed the basis of the present breeding flock).

The captive flock maintained at Patuxent was primarily derived from 50 eggs collected from wild nests in Canada between 1967-74. Progeny raised from these eggs first started laying their own eggs in 1975 when 1 female laid 3 eggs. From 1975-81, 91 eggs were produced by the captive birds and 10 chicks have been reared in captivity (9 of which survive). Three other whoopers fledged from eggs which were successfully cross fostered to wild greater sandbill cranes in Idaho in 1979 and 1980.

Current research at Patuxent is aimed at rectifying earlier problems associated with captive rearing. These problems included absence of normal copulatory behavior in adults and the development of leg and toe abnormalities among newly hatched young. Normal copulation does not occur, consequently, females are artificially inseminated and egg fertility is only 55-80% (Derrickson and Carpenter 1982).

In the mid 1970 s, sandhill chicks reared by parents showed normal copulatory behavior when they reached sexual maturity. As a consequence, beginning in 1978, propagation procedures for whooping cranes (at Patuxent) were modified to exclude machine incubation and hand rearing. Young have been hatched and reared by foster parent sandhill cranes. Young produced in this manner appear more robust, vigorous, and wild and they have not developed leg or toe abnormalities previously experienced from machine incubated and hand reared chicks.

Whooping crane foster parent experiment

In 1975, The U.S. Fish & Wildlife Service and the Canadian Wildlife Service initiated a cooperative experiment to reintroduce the endangered whooping crane into the Rocky Mountain region of the United States. The reintroduction technique involves collecting whooping crane eggs from wild nests in Wood Buffalo National Park; transporting them by aircraft to Grays Lake National Wildlife Refuge, Idaho; and placing them in nests of greater sandhill cranes. Starting in 1976, some eggs laid by captive cranes at Patuxent Wildlife Research Center have been transported to Idaho.

Results to date indicate that cross-fostering is a viable technique for reintroducing whoopers into a new geographical area. Whooping crane eggs were successfully transported from Canada and Maryland to Idaho and substituted into nests of sandhill cranes. Sandhill crane foster parents accepted and hatched whooping crane eggs and reared the young. Young whoopers, in turn, accepted their foster parents and normal family bonds were maintained. Between 1975-81, 71 eggs from Canada hatched and 26 (36.6%) young fledged. From 1976-81, 16 eggs from Patuxent hatched and 3 (18.8%) young fledged. Recent changes in methodology at Patuxent (natural incubation before egg transfer and culling out infertile eggs before shipment) have raised the percentage fledged until it is similar to that of eggs from the Wood Buffalo Park flock. Major causes of chick mortality between hatching and fledging have been inclement weather, drought, and predation by coyotes (*Canis latrans*).

Young whooping cranes surviving to 2 months of age were captured annually and color marked with plastic leg bands for individual identification. Color marking enabled researchers to assess mortality and to monitor the crane's daily and seasonal movements and behavior. In 1979 and 1980, 10 young whoopers were also radio tagged with 45-65g transmitters attached to colored plastic leg bands and portions of the fall migrations of 2 individuals monitored by aircraft.

Foster parent families have successfully migrated to traditional sandhill crane wintering areas in west central New Mexico, primarily the Bosque del Apache National Wildlife Refuge. Young whoopers maintained normal family bonds with their foster parents for 8-10 months and have maintained essentially the same migratory traditions, diets, and daily and seasonal activity patterns learned from their foster parents.

A minimum of 13 whooping cranes, ranging from 1.5 to 6.5 years of age, were present on winter areas in New Mexico during the winter of 1981-82. The sex of these 13 individuals, as determined by unison calls, includes 9 males, 3 females, and 1 is currently undetermined. The biased sex ratio favoring males suggests that a differential mortality of females exists, although sex ratios at hatching and fledging are unknown. Three of the oldest males have established breeding territories at Grays Lake National Wildlife Refuge but lack females. Until pairing and reproduction occurs, the final outcome of the experiment remains unknown. Individual whoopers occasionally have formed temporary associations but no permanent pair bonds have been established; however, the oldest surviving female is only 3.5 years old. Crossbreeding with sandhill cranes was a concern of some scientists when the research project was first proposed, but, whoopers have not attempted to pair with sandhill cranes.

SANDHILL CRANE

Sandhill cranes are, with the exception of those that nest in Siberia and Cuba, restricted to North America. Adults weigh from 2.72 to 5.44kg. Immatures have rusty brown plumage on the body and crown until the postjuvenile molt is complete at 5-10 months of age. The body plumage of adults is slate gray except when stained a rusty brown in summer by ferric oxide when the cranes preen themselves with marsh debris. Adults have dark red papillose skin on the crown.

Six subspecies are presently known. Size, head profile, and coloration are used to distinguish subspecies. The lesser nests in tundra and boreal forests of Siberia, Alaska, and Canada; the Canadian nests in central Canada; and the greater nests in the Lake States, the northwestern United States, and the extreme southern edge of Canada. These 3 subspecies are migratory. The other 3 subspecies are sedentary; the Mississippi in Jackson County, Mississippi; the Florida in Florida and extreme southeastern Georgia; and the Cuban in Cuba.

There is disagreement over the validity of the Canadian subspecies (Stephen et al. 1966, Johnson and Stewart 1973, Walkinshaw 1973:81). There is considerable overlap in body measurements and coloration of lesser and Canadian and between Canadian and greater sandhills (Walkinshaw 1949:6-20, 1965, Aldrich 1972).

Historical distribution

In the early 1800s, the migratory subspecies of sandhill cranes nested in wetland habitats over much of eastern Siberia, Alaska, Canada, and the northern United States as far south as northeastern California, northern Arizona, Utah, western Colorado, central Nebraska, northern and eastern Iowa, southern Illinois, central Indiana and Ohio, and the southern borders of Lake St. Clair and Lake Erie. The nonmigratory subspecies also nested in Alabama, Georgia, Florida, Louisiana, Mississippi, Cuba, and the Isle of Pines. Cranes disappeared from many nesting areas as a consequence of shooting for food, drainage of wetlands, settlement, and general disturbance by man. The decline in their population was most rapid between 1870 and 1915 (Walkinshaw 1949:130). Cranes no longer nest in Alabama, Ohio, Indiana, Illinois, Iowa, Louisiana, Nebraska, the Dakotas, Arizona, and most of the southern portions of British Columbia, Alberta, and Saskatchewan.

Crane hunting was outlawed in the United States and Canada by the Migratory Bird Treaty Act in 1916. Since then, populations of Canadian, greater, Florida, and lesser cranes have increased as a consequence of protection of the birds and their habitat. In the 1930's there were only a few dozen nesting pairs in southern Michigan and Wisconsin (Henika 1936, Walkinshaw 1949:134) in contrast to today's population of more than 700 pairs. The Rocky Mountain population of greater, the lesser, and the Florida subspecies have also increased markedly. The greater subspecies was removed in 1973 from the U.S. Fish & Wildlife Service's list of rare and endangered wildlife of the United States. The Mississippi subspecies is endangered.

Increasing populations and crop depredations led to open hunting seasons on lesser and Canadian subspecies in the United States in 1960 and in Canada in 1964. Sandhill cranes are presently hunted as game in 9 states of the United States, 2 Canadian provinces, and in Mexico. Under proper management, some populations can continue to increase and efforts can be made to reestablish cranes in nesting habitat now unoccupied.

Greater Sandhill Cranes

Five populations of greaters are now recognized in North America (*Table 1*). The Eastern population contains some 15,000 birds and is increasing (Lovvorn and Kirkpatrick 1982. The principal nesting range is in Minnesota, Michigan, and Wisconsin, and possibly in east central Manitoba and western Ontario. Cranes in this population migrate through Illinois, Indiana, Ohio, Tennessee, Kentucky, and Georgia. Eastern greaters use the Jasper-Pulaski (State) Wildlife Management Area in northern Indiana as the major spring and fall concentration area. Most of these cranes winter in Florida but smaller numbers winter in Georgia and Alabama (*Fig. 1*).

The Rocky Mountain population consists of about 16,500 birds, from west-central Montana, south and west through central and eastern Idaho, western and central

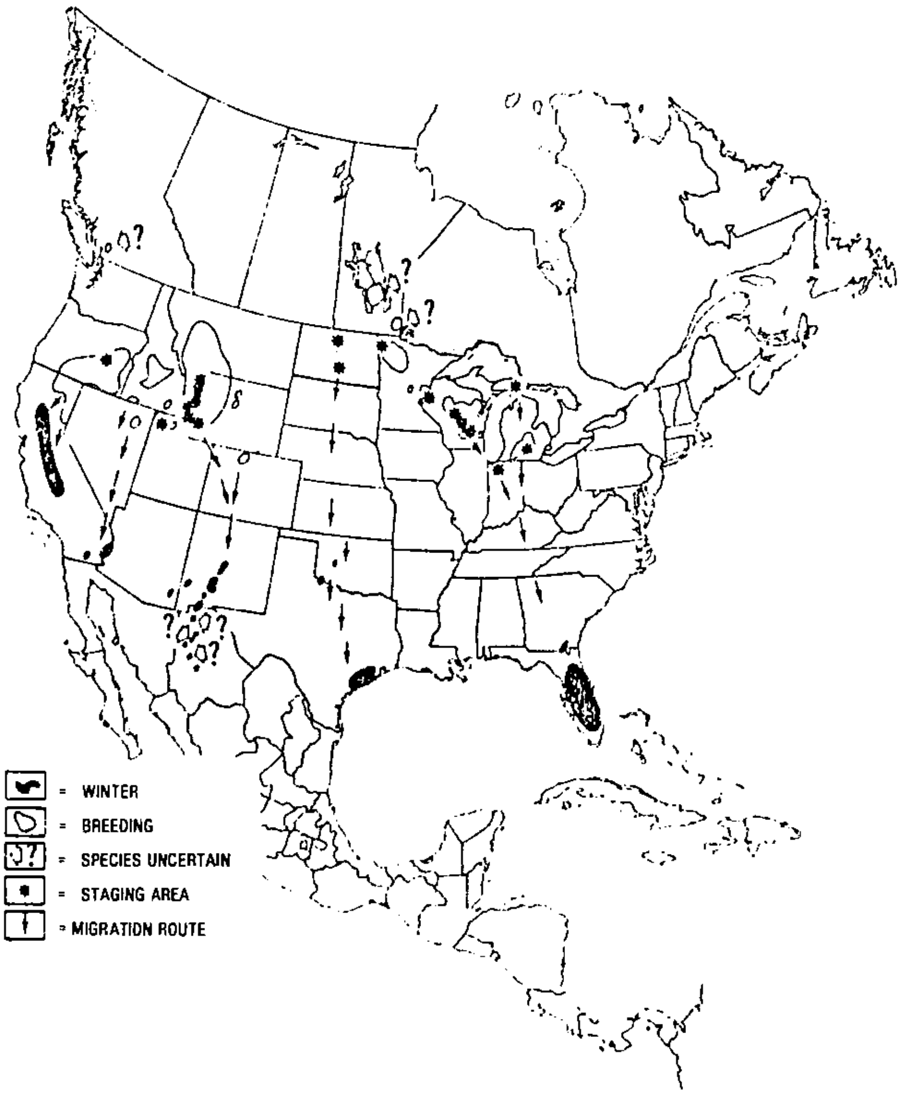

Fig. 1. Occupied nesting range, migration routes, staging areas used during migration, and winter areas for the greater sandhill crane.

Wyoming, and northern Utah to northwestern Colorado. The major spring and fall stopover area is the San Luis Valley, Colorado, where virtually the entire population spends 3-4 months annually. The principal wintering area is the middle Rio Grande Valley, New Mexico, primarily at the Bosque del Apache National Wildlife Refuge. Smaller numbers winter in southwestern New Mexico, southeastern Arizona, and southward to Chihuahua and Durango, Mexico.

Table 1. Population estimates of subspecies of sandhill cranes.

Subspecies	Population	Trend for past decade
Greater (populations)		
Central Valley	3,000-3,200	Stable
Lower Colorado River Valley	1,500-1,600	Unknown
Rocky Mountain	16,500	Increasing
Eastern	15,000	Increasing
Coastal Texas	5,000	Unknown
Lesser and Canadian on Platte River staging area	540,000	Increasing
Lesser in California	25,000	Stable
Florida	5,000-6,000	Stable
Mississippi	30-40	Stable to decreasing
Cuban	Unknown	Unknown

The lower Colorado River Valley population contains about 1,500-1,600 cranes and appears to be increasing. The principal nesting region is in northeastern Nevada and probably northwestern Utah and southerwestern Idaho. Many of these cranes gather each fall in Ruby and Lamoille Valleys in Nevada and pass through Lund, Nevada, a favorite spring staging site. The population winters along the Colorado River and the major winter site is near Poston, Arizona. Some birds winter near Buckeye, Arizona and Brawley, California.

The Central Valley population contains an estimated 3,000-3,200 birds with numbers being static for the past decade. They nest in eastern and southcentral Oregon and northeastern California and winter in the Central Valley of California, primarily from Butte County south to Tulare County. Small numbers of cranes nesting in eastern Washington and central British Columbia are believed to be affiliated with the population. Most of the population gathers each fall at Malheur NWR, Oregon before migrating to their winter quarters.

The fifth population, termed the Coastal Texas population, nests in western Minnesota and southern Manitoba and winters in eastern coastal Texas (Guthery and Lewis 1979, Melvin et al. unpublished). Consequently, the greater subspecies population continent-wide totals about 41,000 birds.

Lesser and Canadien subspecies

The nesting range of sandhill cranes in Canada is not precisely known because they occupy remote areas, however, it includes 5 habitat types. The Canadian prairies and transition zone, the cordillera and West Coast, the boreal forest of the Canadian Shield are probably of least value as breeding habitat. These 3 habitats are limited by industrial and agricultural development, rock outcrops, and deep, steep-shored wetlands and lakes. The best habitat is believed to be tundra and the boreal and mixed forest on the plains south of the Canadian Shield and in the Mackenzie Valley lowlands (Lewis et al. 1977).

Lesser and Canadian sandhills winter in the southwestern United States and in Mexico (*Fig. 2*). Lessers generally are more prevalent than Canadian subspecies in the southernmost winter areas. The largest winter concentration occurs around Muleshoe National Wildlife Refuge in Texas, where the cranes roost at alkaline lakes and feed in

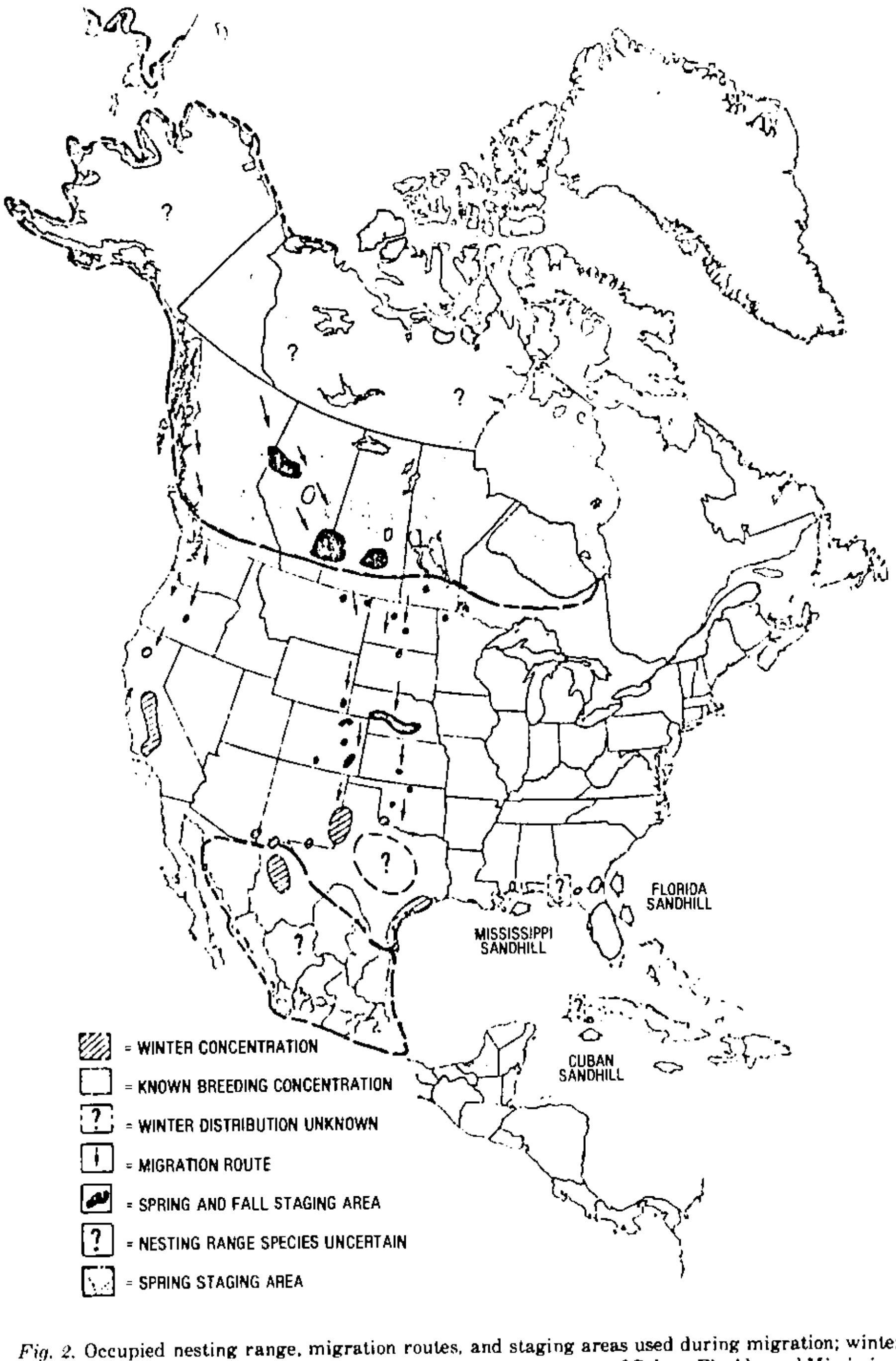

Fig. 2. Occupied nesting range, migration routes, and staging areas used during migration; winter areas for Lesser or Canadian subspecies, or both; and occupied range of Cuban, Florida, and Mississippi races.

nearby grainfields. Crop depredations have been a problem there. The principal wintering area in Mexico is in Chihuahua State, encompassed by Laguna de Guzman on the north, Laguna de Babicora on the west, and Laguna Bustillo on the south (Buller 1982). Wintering populations of lesser and Canadian subspecies seem fairly mobile, and birds move as necessary in response to weather, water conditions, and local food supplies.

Cranes apparently leave wintering areas and fly to the Platte River, in Nebraska with only brief stops along the way. In the Platte Valley they use 3 types of habitat; (1) shallowly submerged sandbars in broad stretches of river as roosting sites; (2) wet meadows, particularly those near roosting areas, for feeding and loafing; and (3) corn stubble, alfalfa, and meadows as feeding sites. Several factors have altered and are affecting habitat in Nebraska. The construction and use of interstate Highway 80 north of the Platte River have greatly reduced the use of nearby meadows and fields by cranes. Farm development subsidies (cost sharing programs) and price supports on crops raised on new lands have helped stimulate conversion of wet meadows to cropland. Water diversions for irrigation, and other water development projects upstream, have altered seasonal rates of water flow and reduced total flow of the Platte. A dramatic change in the river has resulted over the past 3 decades — stretches that were broad and open, with shallow water and submerged sandbars, have been filled by willows and other vegetation. Cranes seem to be shifting to parts of the river that have remained relatively open, such as the area from Grand Island westward 21km. Additional diversion schemes threaten to accelerate the succession from open sandbars to rank willow thickets.

Florida subspecies

The Florida subspecies is restricted to Florida and the adjacent Okefenokee Swamp in Georgia; 5,000 to 6,000 reside in the peninsula of Florida and nest in open wet areas. Typical habitat contains small, shallow lakes with sparse emergent vegetation, surrounded by prairies and improved cattle pastures. Florida cranes avoid densely wooded areas, brackish and saltwater marshes, urban situations, and marshes with dense vegetation such as cattail or saw grass. The landscape and visibility in the peninsula are similar to those of crane habitat in northern Florida, but more open and often drier except in ponds and marshes. Extensive drainage projects and real estate development have destroyed or threatened much of the habitat.

Mississippi subspecies

The Mississippi race occurs only in Jackson County, Mississippi. A portion of the flock is protected by the 6,100ha Mississippi Sandhill Crane National Wildlife Refuge, established in 1974. The present population estimate is 40-50 wild individuals. In January 1981 and January 1982, a total of 14 captive parent reared Mississippi sandhills from Patuxent Wildlife Research Center were released on the refuge to supplement the wild population. The results to date are encouraging — 7 of the 9 released in 1981 still survive, and 1 bird appears to have successfully paired with a wild conspecific. Habitat is open flatwoods containing slash pine, longleaf pine, and moist, meadowlike ground cover.

Cuban subspecies

The Cuban subspecies is restricted to western Cuba and the Isle of Pines. Large savannahs are used for feeding, roosting, nesting, and rearing of young in foothills or pine flats, usually near streams (Walkinshaw 1949:100; 1953). Most nests are on dry upland, but some have been found in small pools of water. L.H. Walkinshaw (1953) estimated that 200 were still living in Cuba. The present population is unknown, but a letter to Walkinshaw from Abelando Moreno indicated that the population was increasing (Lewis et al. 1977).

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CHAPTER VI

EDITORS' INTRODUCTION: TECHNIQUES FOR CRANE MANAGEMENT

In recent years, techniques have been refined to study cranes in the wild, to maintain and propagate cranes in captivity, and to return captive-produced birds to the wild. Crane conservation programs are significant in that widely divergent fields of research have been integrated to maximize success. Captive breeding efforts are not just producing species banks for potential reintroduction in the distant future. Accomplishments in habitat protection have preserved suitable areas for initiating reintroduction efforts. In conjunction with these accomplishments, advances in captive breeding have enabled us to produce sufficient numbers for research on reintroduction techniques. These studies have made it possible to develop techniques and to successfully release cranes in some areas. Radio telemetry techniques have revolutionized the study of crane migration. The resulting information is not only important to the understanding and protection of the wild populations, but is critical to the planning of reintroduction programs. Although there have been many noteworthy accomplishments, management programs for both captive and wild cranes will have to increase dramatically in both sophistication and scope for cranes to survive the pressures of the coming decades.

RADIO TELEMETRY TECHNIQUES FOR INTERNATIONAL CRANE STUDIES

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ABSTRACT

Sandhill Cranes (*Grus canadensis*) have been successfully radio marked with transmitters mounted as backpacks or attached to plastic leg bands. Leg band radios powered by solar panels and rechargeable NiCd batteries are now the most commonly used means of radio marking Sandhill and Whooping Cranes (*G. americana*). Radios mounted on tail feathers are not recommended for crane studies. Characteristics of the radio packages, techniques of attachment, and advantages and disadvantages of each method are described. Cranes can be radio tracked with hand held antennas or antennas mounted on ground vehicles, aircraft, or fixed towers. Combined efforts of radio trackers on the ground and in aircraft are essential if radio marked cranes are to be tracked successfully throughout entire migrations. Variations in the roles and responsibilities of ground versus airborne trackers result in trade-offs between expense, mobility, the probability of maintaining contact with radio marked cranes, and the types of data collected. Techniques used in long distance radio tracking studies of Sandhill Crane migration are described.

Much has been learned about the ecology of Sandhill and Whooping Cranes in recent years through the use of radio telemetry (Nesbitt 1976, Melvin 1978, Toepher and Crete 1979, R.K. Anderson, D.K. Jansen, and T. Cogger, unpubl. rep., U.S. Fish and Wildlife Service, Twin Cities, Minnesota, 1980, Drewien & Bizeau 1981, U.S. Department of Interior 1981, Drewien et al. 1982, Melvin 1982, Zwank & Derrickson 1982, Melvin and Temple 1983, E. Kuyt pers. comm.). Basic information on the components of radiotelemetry systems and techniques of radio tracking can he found in reviews by Brander and Cochran (1971) and Cochran (1980), as well as in catalogues published by commercial suppliers of radiotelemetry equipment. Our objectives in this paper are to review methods that have been used to radio mark cranes in North America, and to describe techniques that we have found useful in long-distance radio-tracking studies of Sandhill Cranes (Melvin 1982). It is hoped some of these techniques can be applied to studies of cranes in other parts of the world.

ATTACHMENT OF RADIO PACKAGES

Back mounted radios

Back mounted transmitters were, until recently, the most commonly used type of radio package for crane research. Back-mounted transmitters were first used in 1973 on non-migratory Florida Sandhill Cranes (*G. c. pratensis*) (Nesbitt 1976), and were subsequently

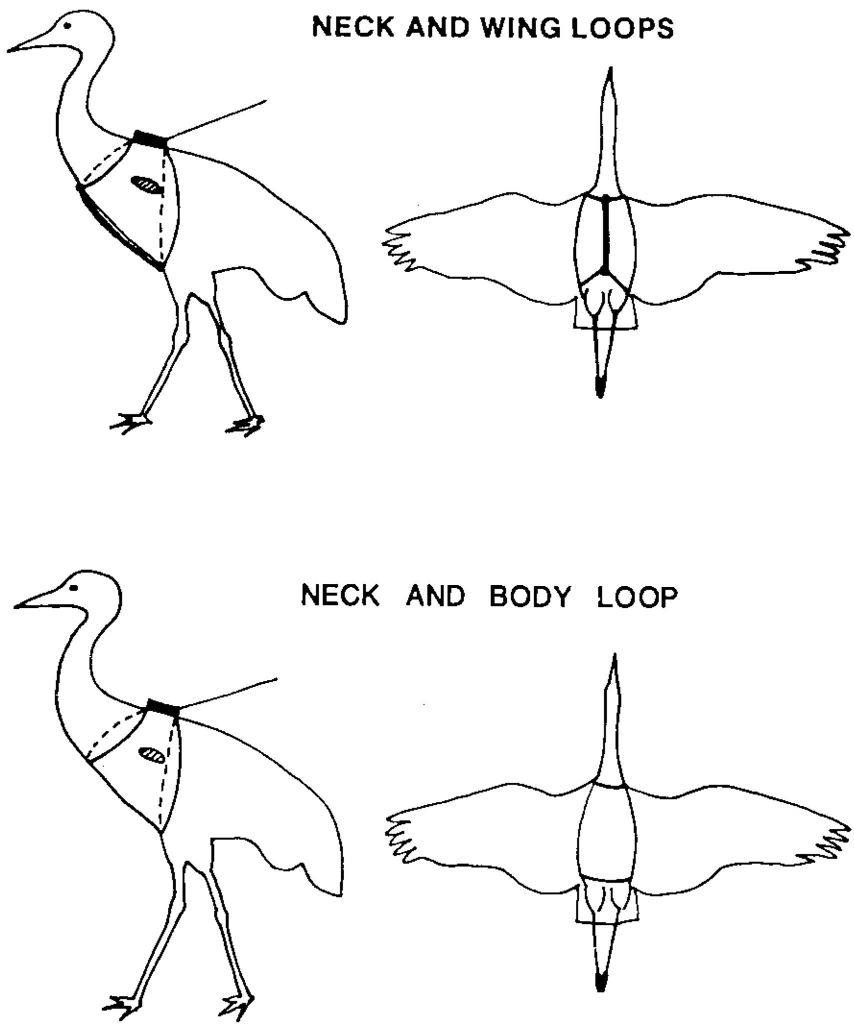

Fig. 1. Harness designs used successfully to radio mark Sandhill Cranes with back mounted radio transmitters.

used to study Sandhill Cranes in the upper Midwest and Florida (Melvin 1978, Toepfer & Crete 1979, Anderson et al., unpubl. rep., U.S. Fish and Wildl. Serv., Twin Cities, Minn., 1980) and in the Central Flyway (Tacha et al. 1982, U.S. Department of Interior 1981, Melvin 1982, Melvin & Temple 1983). Frequencies of these transmitters have generally been in the range of 150-152 MHz or 164-165 MHz.

Back mounted transmitters are attached to cranes with harnesses made of plastic tubing (Nesbitt 1976), plastic-coated wire (Melvin 1978), or plastic coated wire threaded through polyethylene tubing (R.A. Crete and J.E.Toepfer, unpubl. rep., U.S. Fish and Wildl. Serv., Twin Cities, Minn., 1978). The harness consists of neck and wing loops (Dumke & Pils 1973, Crete and Toepfer, unpubl. rep., 1978, Melvin 1978) or a neck and body loop combination (Melvin unpubl. data), similar to that used on waterfowl (Dwyer 1972) (*Fig. 1*). Williams (1981) noted that a third harness design consisting of 2 underwing loops proved unsatisfactory on Sandhill Cranes in Florida, because it allowed the radio package to slide down the crane's back when standing upright.

Weights of back-mounted radio packages, including harnesses, range from 70 to 200g, about 1.5-4% of a Sandhill Crane's body weight. Components include a transmitter and 1 or more mercury or lithium batteries, all encased in a waterproof material such as dental acrylic (Melvin 1978), Scotch Cast #5 resin (Crete and Toepfer, unpubl. rep., 1978), or a paraffin and epoxy mixture (S.M. Melvin and S.A. Temple, unpubl. rep., U.S. Fish and Wildlife Serv., Washington, D.C., 1980). Battery lives have ranged up to 18 months. A whip antenna usually projects from the posterior end of the package, and points up from the bird's back.

We believe that the neck and wing loop design offers a safer and more secure attachment than the neck and body loop design (*Fig. 1*). With the former, the neck loop positions the radio high on the crane's back and supports most of its weight when the bird is standing, while the 2 wing loops, adjusted loosely enough to prevent chafing of the wings, prevent the radio from moving sideways or sliding up the neck. We suspect that use of the neck and body loop design increases the chances that the crane may be able to slip out of the harness or, worse, that the body loop may slip down and become entangled with the upper legs. When fitting cranes with this type of harness we noted that the body loop tended to slide up and down the lower belly, often resting against the upper thighs. At least one juvenile Sandhill Crane that we radio marked in Manitoba with a neck and body loop harness slipped out of the harness within 45 days.

Back mounted radios are useful for studies of adult nonendangered species of cranes, because larger and heavier batteries can be used than with other attachment methods. Also, the radio package can be positioned high on the bird's back with the antenna pointed up and away from its body, thus increasing the range of reception of the transmitter. Use of solar powered back mounted radios on cranes (S. Nesbitt pers. comm.) will allow increases in transmitter life and power over radios powered solely by batteries.

Leg band radios

The design and specifications of radio packages attached to plastic leg bands are described in detail by Melvin et al. (1983), and will only be summarized here. These radio packages consist of a 2-stage transmitter generally in the 164-165 MHz frequency range, powered by a combination of solar panels and rechargeable nickel-cadmium (NiCd) batteries. The package is potted in dental acrylic and then attached with glue, dental acrylic, or tiny bolts to the outside surface of a 7.7-8.0cm high, 19-22mm inside diameter, plastic leg band. The entire package with leg band weighs from 45-75g and carries a 21-24cm whip antenna that extends down the leg of the crane.

Solar panels on leg band radios allow substantial increases in effective radiated power (signal strength) and theoretical life without major increases in weight. Solar panels provide energy to power transmitters during daylight hours and recharge batteries. Batteries power transmitters after dark and permit radiolocations of cranes at night. The internal resistance of NiCd batteries gradually increases with repeated rechargings and ultimately becomes the limiting factor in battery life (Patton et al. 1973); estimated battery life is about 2 years. After the NiCd batteries are no longer rechargeable, solar panels will continue indefinitely to power transmitters during daylight hours, barring physical damage to radio packages.

Ground-to-ground transmission range of leg band radios varies from 2.4 to 6.4km in flat to hilly terrain, and ground-to-air range (trackers flying 900-1,000m above ground) varies between 15-35km. Signals from radio-marked cranes in flight have been received by trackers in aircraft at distances up to 160km. Signals from airborne cranes have been received by ground tackers up to 56km. Signal reception depends upon the power of the individual transmitter, polarization of its antenna relative to the receiving antenna, and relative elevations of transmitting antenna, receiving antenna, and intervening terrain.

Melvin et al.(1983) instrumented 43 Sandhill and 11 Whooping Cranes with leg-band radios between 1978-1981, and tracked some of these birds continuously during migration up to 2,500km (Drewien & Bizeau 1981, Melvin 1982). Leg band radios have also been used to monitor movements of captive-reared Sandhill Cranes released into the wild in Idaho (Drewien et al. 1982) and Mississippi (Zwank & Derrickson 1982). As noted by Melvin et al. (1983), leg band radios appear safer than back-mounted radios and are preferable for use on juvenile cranes and endangered species because: (1) leg band radios pose no risk of entanglement, unlike the harnesses of back mounted radios, (2) radioes bolted to leg bands can be attached more rapidly in the field than can back-mounted radios, and (3) cranes instrumented with back-mounted radios have sometimes shown abnormal behavior, such as reluctance to fly, during the first week after radio marking (Nesbitt 1976, Melvin 1978).

The major disadvantage of leg-band radios for cranes is the problem of antenna breakage, caused when cranes pull, bend, and eventually break the antenna wire. Antenna breakage sharply reduces the range of transmission and makes tracking more difficult and, in some cases, impractical. This problem can be alleviated in part by increasing the diameter of antenna wire from 0.8mm (1/32 in) to 3mm (3/32 in), and by reinforcing the base of each antenna with stronger springs and additional plastic sheathing (Melvin et al. 1983). Another disadvantage of leg band radios is the position of the whip antenna, which hangs down the crane's leg with the distal end only a short distance above the ground. This is an inefficient position for radiating power from the transmitter, and reduces the theoretical transmission range that could be achieved if the transmitting antenna were positioned higher on the crane's body. With the use of solar cells, however, this relatively inefficient antenna disign is offset by increasing the power output of the transmitter; thus, leg band radios for cranes can be designed that are comparable in power output and life to back pack radios powered solely by batteries.

Tail mounted transmitters

Although to our knowledge cranes have not been radio marked in the wild with transmitters attached to tail feathers, this technique has been used successfully with several species of raptors (Dunstan 1973, Fuller & Tester 1973, Cochran 1975). In February, 1979, we radio-marked an adult female Sandhill x Whooping Crane hybrid at the Patuxent Wildlife Research Center, Laurel, Maryland, with a "dummy" solar and battery-powered transmitter with 22cm whip antenna. Total weight of the package was 20g. The radio was attached to the dorsal surface of the central tail feather, after first cutting away 5cm of the vane from both sides of the shaft. The radio components were potted into a base of dental acrylic, the bottom of which was grooved to fit about the shaft of the feather. The shaft was cemented into the groove with Eastman 910 adhesive, and then covered with a final layer of acrylic. Two days following its attachment, this radio package was still securely fastened to the feather shaft, and the female had shown no signs of being unduly disturbed by its presence. However, within 1 week the feather bearing the radio had dropped or been pulled from the tail.

Our observations suggest several disadvantages that make tail feathers unreliable attachment points for radio-marking cranes, given the other means of attachment available. Radio packages mounted on tail feathers cannot be as heavy as back-pack radios, resulting in reduced transmitter life and power. Use of solar panels on tail-mounted transmitters is impractical, as the radios would be covered by the cranes' long tertial feathers except when in flight. Thus, a tail mounted radio would have to be powered solely by batteries, and would have a reduced power output and shorter life than a solar/battery-powered leg band radio of similar weight.

It is not known for how long a crane's tail feather could continue to support the weight of a radio package, or whether the added weight might damage the feather or induce an early molt. Tail-mounted radios would be unsuitable for immature cranes since the tail feathers would not be fully developed at the time of radio marking. A study by Stephenson (1971) of feather molt in immature captive Whooping Cranes found that the retrices in 75-day old birds (approximately the age at which wild Whooping Cranes are banded) were 3 in (7.5cm) or less in length, only half of the 6 to 7 in (15 to 17.5cm) length of a fully grown

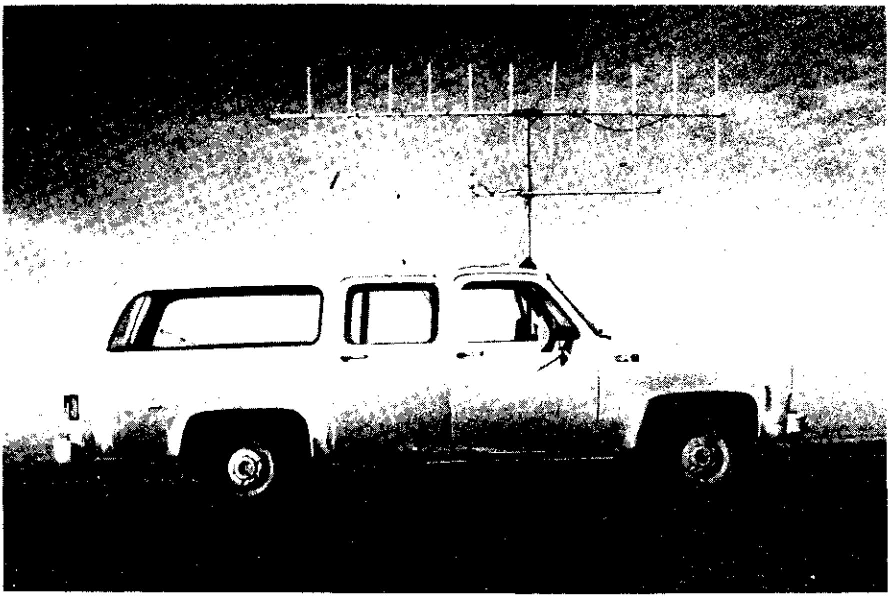

Fig. 2. Vehicle equipped with 11-element Yagi directional antenna. A rotating antenna mast projects through a hole in the roof into the cab, allowing bearings to be taken while the vehicle is in motion.

feather. Attaching a radio to such a half grown feather might result in the feather being damaged and soon lost. Even if it did not drop, after the feather had grown to full size, the transmitter would be attached almost halfway out on the shaft, in a position that would place added stress on the feather.

RADIO TRACKING TECHNIQUES

Receiving antennas

Radio-marked cranes in North America have been tracked using 3, 4, 8, or 11-element Yagi antennas in conjunction with a variety of commercially-available portable receivers. Three and 4-element antennas can be carried by researchers on foot, or mounted on aircraft, while the 8 and 11-element models can be mounted on ground vehicles (*Fig. 2*). Increasing the number of antenna elements increases the directivity of the peak signal received (preciseness of the bearing to the transmitter) as well as the gain (amplification of the received signal). Increasing the height of the receiving antenna above the ground is the most effective way to increase the gain and thereby increase the range of one's receiving system.

Antennas can also be mounted on fixed towers of variable height (Brander & Cochran 1971) (*Fig. 3*) for localized studies of radio marked cranes. At least 2 towers with antennas are necessary to permit accurate radiolocations via triangulation. Antennas on towers can also be used to monitor cranes in flight over long distances; an antenna on a 20m-high tower would theoretically be able to track a radio marked crane for at least 160km (100mi). Tower-mounted receiving systems could be used to minitor the passage of migrants and record their departure bearings, or to detect the arrival of radio marked cranes on breeding or wintering grounds or at migration stopovers. Such techniques could prove useful in long distance migration studies of cranes where funds were unavailable for more expensive tracking techniques or where it was unfeasible for trackers in aircraft or ground vehicles to cross international borders.

Fig. 3. Radio-tracking antenna mounted on a fixed tower. Note that tower is high enough to support antenna above tree line, thus maximizing range of reception.

Long distance radio tracking

Long distance radio tracking of cranes is considered here as the following of one or more radio-marked individuals during all or a substantial portion of their migratory journey. This probably includes several migratory flights interspersed with time spent at staging and stopover areas (Melvin & Temple 1982), and involves radio-monitoring for periods of weeks or months. Cochran (1972a, b, 1975) and Cochran et al. (1967) have reviewed many of the techniques for long-distance tracking of migrant birds, including thrushes, raptors, swans, and geese. Our objective is to describe and discuss some of these and other tracking techniques that we have used to track Sandhill Cranes through entire migrations of 2,560km (1,600mi) between Canada and the United States (Melvin 1982, Melvin & Temple 1983).

The combined efforts of both a ground tracking crew and airborne trackers are essential if a radio-marked crane is to be tracked successfully throughout its entire migration. This is particularly true if the objectives of the project go beyond simply approximating migration routes and chronology, and seek to determine precisely flight paths and speeds, altitudinal changes, effects of wind and other weather variables, behavior of the birds both in flight and on the ground, and locations and characteristics of migration habitat. As Cochran (1972a) has noted, for long-distance radio-tracking to be successful, techniques must be used that provide for a high probability of success on each migratory flight. This, combined with investments of time and money that accumulate as the migration proceeds, dictates that redundant means be employed. The coordinated efforts of trackers on the ground and in aircraft provide this redundancy for radio tracking migrant cranes.

Radio tracking from a ground vehicle

On the ground we have tracked cranes from a vehicle equipped with an 11-element Yagi antenna (*Fig. 2*), to provide maximum directivity and gain. The antenna is mounted approximately 3.4m (11 feet) above the ground on a rotating mast that projects through a hole in the roof of the vehicle to the front seat; thus the antenna can be rotated 360° to obtain bearings while the vehicle is in motion. A driver and a tracker-navigator comprise the ground crew. An aviation radio mounted in the ground tracking vehicle permits continuous communication with trackers in aircraft.

A ground tracking vehicle is much less expensive to operate than an airplane, so money can be saved if the bulk of the tracking responsibility lies with the ground crew. This of course results in trade-offs between: (1) expense, (2) mobility, (3) the probability of maintaining constant contact with radio-marked cranes over a series of long distance flights, and (4) the quality and quantity of data collected enroute.

A ground crew is more efficient than an air crew for continuous monitoring of cranes that remain in localized areas for days or weeks, and for making detailed on-site evaluations of roosting and feeding habitat. When cranes are grounded by inclement weather, it is likely that the air trackers will also be grounded. In such cases the ground crew provides the only means of contact with the radio-marked cranes, sometimes for several days. During slow to moderately paced migratory flights, the ground crew can assume much of the tracking responsibility, thus avoiding the expense of keeping a plane in the air constantly. The ground crew becomes essential in situations (which we have encountered on more than one occasion) when cranes migrate on days when the cloud cover is low enough to prevent VFR flight by air trackers. Similarly, the ground crew is responsible for tracking during periods when the tracking aircraft is grounded for refueling or repairs.

The mobility of the ground crew is limited by the availability of roads relative to the migration route taken by the cranes. The speed of the ground crew also limits its effectiveness, as does the relatively short reception range of its antenna and receiver when radio marked cranes are not in flight. Thus, the ground crew is relatively ineffective for searching large areas for radio marked cranes that are on the ground. The ground crew is perhaps at its greatest disadvantage at the end of a day's flight, when radio marked cranes land to roost for the night and the range of transmitters decreases by 10 to 20 times. Our experience tracking Sandhill Cranes from Manitoba to Texas (Melvin 1982) indicates that the probability is very low that a ground crew unassisted by air trackers can successfully locate a radio marked crane at all, or even a substantial number of its overnight roosts during the course of an entire migration.

Radio tracking from aircraft

A tracking crew in a fixed-wing aircraft is essential to any long distance radio tracking study of crane migration. Because of greater mobility and increased range of radio reception, tracking from an aircraft is more effective than tracking from the ground for searching large areas for radio marked birds, and for quickly locating "missing" birds or birds that have just landed after a migratory flight. In particular, an aircraft is necessary for tracking fast moving migrants [ground speeds averaging more than 64km per hour (40 mph)] that can rapidly outdistance ground trackers. The use of an aircraft is superior for collecting certain types of data, e.g. information on the altitude of crane migration and the interrelationships between soaring, gliding, and flapping flight (Melvin & Temple 1982). It increases the probability of obtaining complete and accurate observations of flight paths, including track changes in relation to wind or landmarks. Tracking from an aircraft gives a high probability of locating radio marked cranes that have landed at the end of a day's flight, and of quickly guiding the ground crew to the birds at their overnight roost site.

We have done all of our aerial tracking of cranes from "high-wing" aircraft equipped with 4-element Yagi directional antennas attached to each wing strut. Our antenna mounts were similar to those described by Gilmer et al. (1981) and allowed us to position the antennas in either a side-looking or forward-looking configuration, with the antenna elements vertically or horizontally polarized.

When searching large areas for radio marked cranes on the ground we flew at an altitude of about 1000m above ground level (agl) with the antennas in a side-looking configuration. The width of search transects was approximately 24km (15 miles) to either side of the plane, slightly less than the maximum ground-to-air range of our transmitters. The 1000m altitude provided a good compromise between maximizing our range of signal reception and minimizing the time required for descents to pinpoint radio-marked birds and subsequent climbs to resume searching. Gilmer et al. (1981) reported that the maximum signal gain is not increased at altitudes greater than 300m agl over open areas, although higher altitudes may increase sensitivity when tracking over mountainous or forested areas. We found, however, that our range of reception increased at altitudes above 300m, possibly because of the very low position of the transmitting antenna relative to the ground's surface on leg band mounted radios.

In the side-looking configuration, our antennas were usually tilted between 0° and 15° below the horizontal. We occasionally had to lower our flight altitude or tilt the antennas further below the horizontal in order to reduce radio interference coming from distant but powerful radio sources such as large cities, airports, petrochemical refineries, or offshore oil drilling platforms. Particularly strong and persistent interference was sometimes countered by positioning the fuselage of the aircraft roughly perpendicular to the direction from which the interference was believed to orginate, and then searching only with the antenna that pointed in the opposite direction. All of these maneuvers reduced the widths of our transects and thus increased searching time.

Once a signal was received from a crane on the ground, we could locate the birds quickly by using a switchbox to monitor alternately the relative strength of signals coming from each antenna, while making right angle turns with the aircraft, and then homing in on the transmitter by gradually descending and decreasing the diameter of the area being searched (Mech 1974, Gilmer et al. 1981). We were consistently able to pinpoint radio marked cranes on the ground to within 100m or less without flushing the birds.

Tracking airborne cranes from aircraft was slightly more difficult, primarily because (1) the birds were not stationary, and (2) the polarization of each transmitter antenna was constantly changing when the birds were spiralling and as the relative elevations of each transmitter antenna and the tracking antennas changed, resulting in large fluctuations in signal strength. Most of our aerial tracking was done with the antennas in a side-looking configuration, by maneuvering the aircraft back and forth until an approximate bearing to a peak signal could be determined. Fluctuations in signal strength from a spiralling crane often resulted in "false" nulls and peaks, particularly when the bird was some distance away, and this often required several minutes of "averaging" the input from the antennas before a reasonably accurate bearing to a true peak signal could be determined. This bearing could then be constantly confirmed and refined as the aircraft closed in. We could determine whether our airplane was above or below the radio marked crane be dipping or raising the appropriate wing and antenna in order to locate the strongest signal and thus indicate the appropriate angle above or below the horizontal to the bird.

To avoid disturbance during our final approach to establish visual contact with flocks containing radio marked cranes, we would attempt to remain above the suspected elevation of the birds. When we tracked migrating Sandhill Cranes, there were often several flocks flying within 1.6km or less of each other. Once we had sighted a flock in the air, therefore, a few final maneuvers of the plane and its antennas were necessary to verify which flock actually contained the radio-marked crane.

On occasions when we had to overtake migrating cranes that had a substantial headstart, we mounted the antennas in a forward looking configuration and angled approximately 10° outward from the main axis (nose to tail) of the plane. This allowed us to scan the horizon ahead with a minimum of maneuvering, thus speeding our pursuit. Using this technique, we have located and overtaken migrating Sandhill Cranes that had headstarts of as much as 4 hours and 160km (100 miles) (Melvin 1982).

Strategies and tactics for long distance radio tracking

We have used some additional strategies and tactics for long distance radio tracking studies of crane migration. These are based on 2 assumptions (1) that the cranes will initiate each migratory flight during daylight hours, probably before noon, and (2) that the cranes will land to roost each night (Melvin & Temple 1982). Inclusive are tactics that increase the probability that flight paths can be accurately extrapolated and radio marked birds relocated in the event that either of these assumptions is not met.

The first task each morning is to relocate the radio-marked individual before it begins the day's flight or, at worst, reestablish radio contact with the bird soon after it becomes airborne and then relocate it as soon as possible. If the ground crew is able to approach close enough to the roost, it can continuously monitor the crane's radio signal until take-off, and perhaps even observe the departure. If not, it must select a point downrange along the anticipated flight path and monitor continuously until the bird takes flight and radio contact can be reestablished. The ground crew may also elect to monitor from a downrange site in order to get a headstart, particularly on days when tailwinds will speed the bird's flight or when local road systems are poor. Such a monitoring site should be on the highest topographic feature available, to maximize the range of signal reception. The site should have a clear line of sight in all directions, unobstructed by trees or buildings, and should be free of nearby sources of interference such as power lines.

If the ground crew elects to intercept from downrange, it becomes the responsibility of the airborne trackers to confirm that the radio marked crane is still in the vicinity of its overnight roost. The air crew should take off at sunrise and climb immediately to approximately 300m (1000 ft.) agl. There it can maneuver in a slow, wide circle and monitor with 1 antenna in all directions and particularly downrange in the direction the cranes are expected to continue migrating. If the radio marked bird has unexpectedly departed before dawn, this maneuver should detect it in the air within a 80-160km (50-100

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BEHAVIORAL MANAGEMENT OF CAPTIVE CRANES — FACTORS INFLUENCING PROPAGATION AND REINTRODUCTION

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ABSTRACT

The cranes are a relatively small and ancient avian family; the 15 extant species share many biological and behavioral characteristics. Many of the techniques currently used in maintaining and propagating cranes in captivity exploit these common attributes, and consequently can generally be applied, with little or no modification, to a number of species. We describe the relationship and discuss some of the principal behavioral characteristics that have influenced and shaped current methods used in managing, propagating, and reintroducing captive cranes.

INTRODUCTION

Although we do not know with certainty when cranes were first taken into confinement or when the first captive breeding occurred, avicultural interest in cranes has been pronounced, and for several hundred years a variety of species have been maintained periodically in captivity. For example, successful breeding and rearing of the Sarus Crane (*Grus antigone*) is recorded in the diary of the Mogul Emperor Jehangir (A.D. 1605-1627) (Rothschild 1930). Similarly, the first recorded hatching and rearing of a Demoiselle Crane (*Anthropoides virgo*) occurred before 1764, and at least 6 other species—Stanley Crane (*A. paradisea*), Common Crane (*G. grus*), Sandhill Crane (*G. canadensis*), Red-crowned Crane (*G. japonensis*), Brolga Crane (*G. rubicundus*), and Sarus Crane—were successfully bred in captivity between the late 1800's and mid-1920's (Wylie 1978).

At least 7 species and 4 subspecies of cranes are currently considered to be rare and threatened with extinction (Archibald et al. 1981). As wild populations of these species have declined over the past several decades, interest in captive propagation as a conservation strategy (Conway 1980) has been stimulated, and the number of institutions engaged in maintaining and breeding cranes in captivity has increased dramatically. Captive propagation is now generally recognized as a technique that can effectively

(5) Individual behavioral idiosyncracies — Like other animals, cranes display a wide variety of individual temperaments and personalities, especially when held in confinement. To insure early and sustained reproduction in the captive environment it is extremely important to treat each bird as an individual even after it is compatibly paired. As noted by Kepler (1978), long and constant observations are normally required to determine individual idiosyncracies and identify behavioral problems. Once such problems are diagnosed, however, a variety of corrective actions involving environmental modification, technique modification, or behavioral conditioning can usually be initiated to insure breeding. For example, visual barriers can be erected to reduce nervousness or high levels of aggression stimulated by neighboring pairs; if individuals are highly stressed by repeated capture and handling artificial insemination can be withheld until laying commences; and newly formed or loosely bonded pairs can be placed between established pairs to reinforce their pairbond and stimulate territorial behavior. Sometimes a specific behavioral problem can be solved by using one of several alternative techniques. Difficulties in taming wild-caught or parent reared individuals for captive breeding, for example, can usually be overcome by: (1) acclimating the birds to confinement through constant exposure to human activities (i.e., Demoiselle Cranes, Archibald & Veiss 1979); (2) simulating wild conditions through visual and spatial isolation (i.e., Hooded Cranes (*G. monacha*), Archibald & Viess 1979); or (3) pairing wild caught individuals with captive reared mates (Sandhill Cranes, S.R. Derrickson, pers. obs.).

(6) Disturbance and stress — Wild cranes will sometimes abandon their territories and fail to breed if they are disturbed repeatedly during the breeding season. Frequent disturbance can significantly alter the behavior of captive pairs as well, and can foster a variety of stress related health and productivity problems. Because captive cranes are particularly prone to stress while breeding, disturbance levels in the captive environment should be reduced as much as possible in advance of the breeding season. Furthermore, in order to minimize potential stress effects, pairs should be acclimated to necessary breeding season activities before breeding commences. This can largely be accomplished by restricting access to breeding areas to only essential personnel, and by completing all routine husbandry and propagation activities (i.e., nest checking, egg collecting, feeding, artificial insemination, etc.) on a regular daily schedule. Captive pairs should be monitored throughout the breeding season for changes in behavior indicating stress, such as frequent pacing, excessive preening, decreased frequency of precopulatory behavior or unison calling, egg breaking, etc. When such behavioral changes are noted, propagation procedures should be immediately reevaluated and modified. For example, observations during the 1980 breeding season on a sexually compatible pair of Whooping Cranes at the Patuxent Wildlife Research Center revealed excessive pacing by the female. This behavior occurred throughout the day, was not associated temporally with disturbance, and was persistent enough to interfere with normal pair activities. Although the frequency of her pacing decreased following the removal of several visual barriers, it persisted at a reduced level throughout the remainder of the breeding season and the female did not lay. Before the 1981 breeding season, the pair was moved to a more spacious breeding enclosure. Stress related pacing was not observed following this move, and the female laid eggs for the first time. Observations on another compatible pair of Whooping Cranes during the 1981 breeding season revealed that normal pair activities were completely disrupted for several hours following routine capturing and handling for artificial insemination. Because both birds were extremely stressed following handling, all attempts at artificial insemination were halted. Although the pair resumed normal behavior and progreseed to nest building, the female did not lay. In order to avoid this same problem the following year, the pair was not captured or handled for artificial insemination early in the 1982 breeding season. Stress related behavior was not observed, and the birds came into breeding condition rapidly. Semen collection from the male and artificial insemination of the female were resumed after the laying of their first egg without apparent ill effect, and the female subsequently produced an additional 4 fertile eggs.

(7) Diet — Wild cranes are omnivorous; captive cranes are extremely adaptable in diet as well, and have traditionally been provided a variety of foods found by experience to enhance their survival and reproduction. These "mixed" diets have normally combined seeds, cereal grains, chopped meat and fish, insects, and commercial poultry or waterfowl diets in various proportions (Tavistock & Delacour 1928, Rothschild 1930, Pohlman & Knoder 1968, Elgas 1968, Steel 1977). Because dietary imbalances can result from either the improper selection of diet components or selective feeding, there has been an increasing interest in recent years to develop formulated diets for captive animals, and a number of standardized rations have been prepared for cranes (Archibald 1974, Erickson 1975, LaRue 1981, Putnam 1982, Carpenter 1986). To accommodate seasonal changes in nutrient requirements, adult cranes are normally provided separate "breeder" and "maintainer" rations during the breeding and nonbreeding seasons, respectively. The widespread use of these nutritionally balanced diets has greatly improved the productivity of captive pairs, and has substantially reduced the frequency of delayed breeding.

Territoriality and breeding enclosures

Wild pairs of cranes occupy and defend exclusive territories while breeding. Pairs of some species, such as the Whooping Crane (Allen 1952) and Siberian Crane (Sauey 1976), regularly maintain territories during the nonbreeding season as well. Territory size varies considerably within and between species, primarily in relation to the productivity of the habitat, the density of pairs, and the distribution of natural topographic features. Although males are generally more alert and aggressive than females, both sexes participate in territorial defense. Most interactions, however, are resolved without physical conflict with a variety of ritualized postures and vocalizations and with aerial chases.

Like their wild counterparts, captive pairs are territorial and extremely intolerant of conspecifics. Aggressive interactions between pairs in captivity can not only impede reproduction, but can at times result in serious injury and/or death (Carpenter et al. 1976, Archibald & Viess 1979). For this reason, breeding pairs should normally be confined in separate enclosures affording minimal visual contact with neighboring pairs.

Early attempts at captive breeding attempted to simulate natural conditions; breeding pairs were consequently placed in large paddocks after being rendered flightless by pinioning (Lint 1965), tenectomy, or tenotomy (Miller, J.C. 1973). In recent years, however, most institutions have moved towards using smaller enclosures in order to conserve on space and to accommodate an increased number of breeding pairs. For example, at the International Crane Foundation, breeding pairs are housed in pens measuring 12.2 x 18.3m, 18.3 x 18.3m, or 18.3 x 24.4m, depending on the body size of the species (Archibald 1974). Interactions between adjacent pairs are minimized through the use of visual barriers, and the pens are covered with mesh netting in order to accommodate full-winged pairs and prevent birds from jumping into adjoining occupied enclosures (Archibald & Viess 1979, LaRue 1981). At Patuxent, flight restricted pairs of Sandhill Cranes and Whooping Cranes area held in open-topped enclosures measuring 9 x 18m and 17 x 17m, respectively, while full-winged pairs of both species are held in covered pens measuring 17 x 33m. In order to ensure spatial isolation and prevent fighting along common fence partitions, these pens are arranged in linear series, and breeding pairs are housed in alternate enclosures. Because pairs are flanked by empty pens at all times, each possesses, in effect, a psychological territory three times as large as its actual pen. This particular design has not only reduced the need for using visual barriers, but has provided several additional advantages as well. Each fall, breeding pairs are moved to their adjacent enclosures, and this annual rotation has greatly improved pen sanitation and reduced both soil compaction and parasite problems. Furthermore, as noted by Kepler (1978), the empty enclosures can be used for introducing potential mates to unpaired birds without risking physical injury from aggression.

As previously indicated, wild pairs will sometimes abandon their territories and fail to breed following repeated disturbances. The normal progression of breeding behavior in captive pairs can be similarly disrupted if they have not had enough time to establish the psychological security associated with territory, or if this security is diminished through repeated disturbance. It is extremely important, therefore, to isolate pairs in breeding enclosures at least 2-3 months before nesting, and to hold disturbance levels to a minimum throughout the prebreeding and breeding seasons.

Prenesting and copulatory behavior

Wild pairs become extremely vigilant during the prenesting season, and hostile interactions, threat behavior, unison calling, and copulatory activities all increase in frequency. Captive pairs show similar behavioral changes as a prelude to breeding. Because hand reared adults typically direct threat displays and attacks at their human caretakers as well as other cranes, the increased level of aggression associated with nesting is particularly evident in captivity.

Wild pairs normally copulate several times per day, beginning 20-30 days in advance of egg laying. Although captive pairs generally show a similar chronology in copulatory activities (i.e., bill raising, wing spreading, and/or mounting), in many instances these activities do not lead to successful copulation and fertilization. Copulatory problems leading to egg infertility have proven to be fairly common among captive pairs of cranes, and can result from a variety of causes. For example, compatible pairs often exhibit poor fertility during their first several breeding seasons, but regularly produce fertile eggs thereafter (cf. Rothschild 1930, Clarke & Amadei 1969, D'eath 1972). This pattern has been observed in younger pairs of Sandhill Cranes at Patuxent on a number of occasions, and appears to result from copulatory inexperience on the part of one or both pair members. Some captive pairs regularly produce both fertile and infertile eggs each year, and there is no temporal or sequential pattern evident in the distribution of fertile eggs (cf. Conway 1965, Maroldo 1980). Because copulations are obviously occurring in these pairs, such periodic infertility usually results from either irregular semen production by the male, or reduced copulation frequency due to disturbance. Disturbance can cause a dramatic decrease in the copulatory activities of some captive pairs (LaRue 1980, Derrickson, per. obs.). Unsuccessful copulations in captive pairs can also stem from the male's inability to mount and balance properly during copulation attempts as a result of being rendered flightless. This problem appears to be widespread, particularly in the larger crane species (Archibald & Viess 1979), and, consequently, many institutions are moving toward maintaining birds that are either lightly wing-clipped or full-winged. Copulatory problems in many captive pairs, however, seem to be associated with subtle behavioral factors rather than from the aforementioned problems. In such cases, males typically will not even attempt to mount their mate, or will dismount immediately after mounting, despite normal precopulatory displays and female solicitation. Whether this results from abnormal rearing conditions during ontogeny, subtle dominance or sexual incompatibilities, or other inhibiting factors remains unclear at the present time. At Patuxent, we are currently examining possible relationships between rearing methods and adult copulatory problems. Preliminary results suggest that adult copulatory performance is best when birds are reared by parents, intermediate when birds are hand reared in groups, and poorest when birds are hand reared as individuals. Unfortunately, current sample sizes are small, and in many individual cases other potential contributing factors cannot as yet be ruled out. For example, several non-copulatory pairs of Sandhills have suddenly started copulating regularly after being allowed to complete normal incubation activities and to hatch and rear offspring. In these pairs, normal parental activities apparently resolved slight problems in either compatibility or dominance that adversely affected copulatory performance.

Paired females not served by natural copulation for the aforementioned reasons can be artificially inseminated using the massage technique (Archibald 1974, Gee & Temple 1978, LaRue 1980, Putnam 1982). Artificial insemination (AI) can also be used when pair members must be penned separately due to incompatibility, when there is a shortage of sexually mature males for pairing, when an individual will not pair with a conspecific due to improper imprinting, when copulation is prevented due to a permanent physical disability, or when new bloodlines need to be established within a captive flock (Archibald & Viess 1979, LaRue 1980). Because AI necessarily involves repeated capture and handling, there is always a chance that reproductive activities can be adversely affected as a result of injury or stress. For this reason, this technique should only be used after poor reproductive performance has been confirmed during several breeding seasons. Furthermore, in order to minimize potential stress effects, pairs should be conditioned to the manipulations associated with this procedure well in advance of breeding each year. This can normally be accomplished by (1) initiating semen collection from males 3-4 weeks before egg laying, (2) beginning insemination of females as soon as their pubic bones start to separate, and (3) adhering to a regular AI schedule throughout the prelaying period. Some pairs that are easily stressed by repeated capture and handling cannot be readily conditioned to tolerate AI early in the breeding season. As previously mentioned, semen collection and insemination in such cases can usually be initiated after the laying of the first egg or clutch without adverse effect.

Results obtained with artificial insemination can vary considerably, depending upon a variety of factors including the quality and quantity of inseminated semen, the site of insemination (cloaca vs. oviduct), and the timing of insemination in relation to oviposition. However, excellent fertility can normally be achieved from most pairs when females are routinely inseminated three times per week and after each oviposition, and when semen is placed directly into the oviduct. For example, the fertility of artificially inseminated Whooping Crane eggs at Patuxent during the past two breeding seasons was 96 percent (24 of 25 covered eggs) and 91 percent (30 of 33 covered eggs), respectively. These fertility rates are high when compared to previous years (cf. Derrickson & Carpenter 1981), and resulted primarily from the following refinements in AI procedures: (1) consistent deposition of semen into the oviduct as opposed to the cloaca, (2) inseminating females from 2-3 hours after each oviposition, (3) manipulating females to climax following semen deposition, and (4) modifying handling procedures as needed to accommodate the behavioral idiosyncracies of individual birds.

Improving reproductive performance

Cranes are indeterminate layers, and although pairs usually lay only two eggs per year, they will renest if their eggs are lost or destroyed prior to midincubation. In order to increase annual production, aviculturists have generally stimulated relaying in captive pairs either by removing individual eggs as they are laid ("egg-removal") or by removing completed clutches ("clutch removal") (Griswold 1962, Conway 1965, Archibald 1974, Sauey & Brownsmith 1977). Although up to 17 eggs have been obtained in a single breeding season using these techniques, average production per female is usually closer to 8 or 9 eggs. Because egg removal normally results in the production of more eggs than clutch removal (Kepler 1978), many institutions have adopted the former method to ensure maximum production per breeding female. Recent studies at Patuxent on Sandhill Cranes, however, have revealed that clutch size and laying cycles are much more uniform when completed clutches rather than individual eggs are removed from breeding pairs. Because this uniformity allows relatively accurate prediction of laying chronology, AI schedules can be adjusted as required to ensure maximum fertility. For this reason, clutch removal is now being used routinely on most pairs requiring AI at Patuxent, even though overall egg production is slightly reduced.

Captive pairs of several species that typically breed at high latitudes have shown improved reproductive performance when exposed to artificially extended photoperiods. With photostimulation, these pairs tend to lay earlier in the spring and consequently have more time to produce eggs before hot weather halts egg production. This technique has resulted in the successful breeding of Whooping Cranes, Greater Sandhill Cranes (*G.c. tabida*), Siberian Cranes, and Hooded Cranes at a number of different institutions (Erickson 1975, Kepler 1978, Archibald & Viess 1979). In contrast, crowned cranes and Brolga Cranes normally breed during the rainy season in Africa and Australia, respectively, and rainfall appears to be important in stimulating breeding behavior and triggering reproduction. Successful breeding of both species at the International Crane Foundation occurred after breeding pens were equipped with water sprinklers, and pairs were regularly exposed to artificial rainfall (Archibald & Viess 1979, LaRue 1981).

For reasons that are still not understood, the hatchability of fertile Whooping Crane and Mississippi Sandhill Crane eggs laid at Patuxent is higher when they are incubated naturally rather than artificially (Erickson & Derrickson 1981). Because of this, experienced pairs of Florida (*G. c. pratensis*) and Greater Sandhill Cranes are routinely used as surrogate parents to incubate the eggs and occasionally rear the young of both endangered species. These pairs are allowed to begin incubation after laying their second or third clutch, and Whooping Crane or Mississippi Sandhill Crane eggs are later substituted in their nests. Although nest exchanges are more frequent in captive pairs due to disturbance, overall nest attentiveness is nearly identical to that reported for wild pairs. All of the pairs used as surrogate parents have had considerable experience in incubating eggs and rearing chicks, and consequently can be subjected to considerable manipulation without being adversely affected. On many occasions, these pairs have been forced to incubate continuously for periods of 50-76 days due to repeated egg substitution, yet they have not deserted and have successfully hatched young. In other instances, pairs have been given pipped eggs after having completed only 10-12 days of incubation, yet they have successfully hatched these eggs and displayed normal parental behavior.

As previously mentioned, the breeding performance of captive pairs can be significantly enhanced when they are allowed to gain experience in incubating eggs and rearing young. For this reason, we normally allow young pairs to incubate their second or third clutch until hatching. If the eggs prove to be infertile, the pairs are given fertile eggs, and if the chicks die during rearing, the pairs are usually given other similar aged chicks. Several breeding pairs of Whooping Cranes at Patuxent have been allowed to hatch and rear Sandhill Crane chicks during the past few years, and in all cases subsequent breeding performance has improved. Under certain circumstances, chicks can even be adopted to nonbreeding pairs in order to strengthen the pair bond, stimulate parental behavior, and increase the probability of future breeding. As noted by Voss (1974) the adoption of a Sandhill Crane chick to a compatible but inexperienced pair of Red-crowned Cranes resulted in significant changes in the sexual and territorial behavior of both pair members. This technique should obviously receive additional attention in future years.

BEHAVIORAL CHARACTERISTICS OF YOUNG CRANES

Crane chicks have frequently been raised in captivity by their natural parents (cf. Tavistock & Delacour 1930, Ezra 1936, Walkinshaw 1951, Sanfield 1972, Steel 1977). Although this technique is still widely employed, parent rearing generally exposes chicks to a wider array of mortality factors, and severely limits the potential for maximizing the production of individual pairs unless large numbers of surrogate parents are available. For these reasons, the hand rearing of chicks, either individually or in groups, has gained increasing favor in recent years (Archibald & Viess 1979). Many institutions currently use both parent-rearing and hand-rearing techniques in their crane propagation programs.

Crane chicks possess a number of characteristics that have influenced and directed captive-rearing efforts. For example, sibling rivalry in wild chicks is common, and apparently plays an extremely important role in adjusting brood size to the available food supply. Because the dominant chick obtains principal access to the food made available by the parents, subordinate chicks during periods of food shortage die quickly (Miller, R.S. 1973, Drewien 1973). Intraspecific aggression between chicks in captivity can result in serious or even fatal injury, and consequently most institutions physically (but not visually) separate individuals for rearing (Archibald 1974, Archibald & Viess 1979). At Patuxent, we frequently raise 3-4 similar aged chicks together in order to minimize abnormal socialization. This technique works best when chicks are placed together as soon as they are removed from the hatching unit, and when several day old turkey poults are grouped with the chicks. As noted by Erickson (1975), the simultaneous introduction of turkey poults provides added targets for aggression, and results in increased exercise from chasing. Chicks raised in this manner establish a dominance hierarchy relatively rapidly, and aggressive interactions usually become inconsequential after several days. Aggressive behavior can also be reduced by providing multiple feeders and waterers, by placing small visual barriers throughout the rearing pen, and by reducing light intensity by using infrared bulbs as the primary source of illumination (Erickson 1975). When parent or foster parent rearing cranes at Patuxent, we narmally leave only one egg under pairs for hatching and subsequent rearing in order to avoid sibling aggression.

Until they are 7-14 days old, chicks normally receive almost all of their food from their parents. Because hand reared chicks lack normal parental guidance, they have considerable difficulty in identifying and consuming food items unless training is provided during their first few days of life. This can normally be accomplished by suspending a red colored dowel over the food pan so that it just touches the surface of the food. The bright color attracts their attention, and when the chicks peck at the dowel they inadvertantly get a beakful of food (Kepler 1978). An alternative method, recently used at the International Crane Foundation, involves the use of puppet models patterned after the head of the parental species. These models have movable mandibles, and food items can be picked up and presented to the chick (Putnam 1982). Regardless of method, chicks are more readily conditioned to feeding when training sessions are initiated only after they are mobile and hungry (normally 35-40 hours after hatching). Usually 3 to 5 training sessions per day are required for several days before adequate independent food consumption is achieved. Early training is especially important when chicks are being raised in groups, since hunger frequently leads to increased levels of aggression (Quale 1976, Kepler 1978).

Once chicks begin eating regularly, it is extremely important to prevent them from overeating. Excessive weight gains during the period of most rapid growth (2-6 weeks) can result in leg weakness, leg bone deformities, and ultimately death. Leg problems can usually be avoided by regularly walking or swimming chicks to increase exercise levels, and by restricting food intake whenever daily weight gains exceed 10-15 percent of the total body weight (Erickson 1975, Kepler 1978, Archibald & Viess 1979). The severity and incidence of leg disorders can also be reduced by slowing the growth rate with diets of low metabolizable energy and sulfur amino acid content (Serafin 1980, 1981, 1982). Unlike chicks that are hand reared, chicks raised by parents do not develop leg problems, presumably because food consumption is lower and exercise levels are much higher.

Like the young of other precocial species, crane chicks will readily imprint on any vocal or moving objects during their early development. Consequently, in order to avoid abnormal socialization, it is extremely important to maximize visual and vocal contact between chicks and to minimize contact between chicks and their human caretakers. This can be accomplished in a variety of ways including: (1) rearing chicks in groups, (2) providing visual contact between chicks in adjacent rearing pens, (3) placing mirrors in pens when chicks are held alone, (4) exercising chicks in groups, (5) teaching chicks to feed using the red dowel or puppet head techniques, (6) using visual barriers to minimize visual contact between chicks and caretakers, and (7) reducing human vocal contact with chicks as much as possible.

Cranes that are hand raised using "conventional" rearing procedures are relatively tame, and although they breed well in captivity, they are not easily returned to the wild (Nesbitt 1979). In contrast, cranes that have been parent reared in captivity are behaviorally similar to wild birds, show normal copulatory behavior upon reaching adulthood, and appear much better suited for reintroduction to the wild. For this reason, at

Patuxent we have substantially increased our parent rearing effort in recent years, despite the fact that this method increases the risk of mortality due to disease, parasites, and accident.

Rearing techniques are constantly being modified and improved, and eventually it may be possible to hand raise birds suitable for release into the wild. For example, at the International Crane Foundation, two Stanley Cranes were recently hand raised while being visually isolated from people. These birds were taught to feed using puppet models, and were in constant visual contact with an adult pair of cranes. When finally exposed to people at fledging, both birds avoided contact, and exhibited much more nervousness and stress than birds hand raised in the conventional manner (Putnam 1982). These experiments hold considerable promise, and obviously should be continued.

MANAGEMENT OF SUBADULTS

In cranes the period of parental care is prolonged and normally lasts about 10-11 months. During this entire period the chick remains with its parents and gains important knowledge concerning food and feeding methods, roosting areas, migration pathways, wintering areas, and predators. Chicks are abandoned by their parents the following spring prior to the breeding season, and they normally join other juveniles and subadults in nonbreeder flocks.

At Patuxent, chicks that have been hand reared are progressively mixed into larger groups beginning at about 40-50 days of age. Because this progressive grouping can sometimes result in aggression, the birds are closely monitored at this time. The chicks are either wing-clipped or wing-brailed at fledging, and are moved to juvenile quarters at about 3-4 months of age. If birds are to be rendered permanently flightless, this is normally accomplished by tenotomy when they are 4-6 months old. When juveniles are 12 months old they are moved to community enclosures where they are maintained until pairing occurs. To prevent the buildup of soil pathogens, juvenile enclosures are occupied 1 out of every 3 years, and community enclosures are occupied 1 out of every 2 years.

By the time chicks are moved into the juvenile quarters, the intense aggression characteristic of the rearing period has waned, and the birds become quite gregarious once a dominance hierarchy is established. These hierarchies are primarily linear, with larger birds being dominant over smaller birds, and males being dominant over females (Kepler 1976, Viess 1982). Because dominant individuals will occasionally monopolize access to food and water, both the juvenile (16 x 76m) and community (40 x 60m, and 60 x 180m) enclosures are large, and contain multiple feedsheds and waterers. Once dominance hierarchies are established, attempts to introduce single birds or small groups can result in considerable aggression. For this reason, these activities are normally conducted whenever birds are being moved en masse from one enclosure to another.

As subadults approach their second year, sexual activities and hostility increase and it is at this time that pairbonds begin to form. Established pairs can be recognized by their constant association, their hostility toward conspecifics, and their frequent Unison Calling. As previously mentioned, pairs should be moved from the community enclosures to breeding pens as soon as they are identified. In some instances, an individual male will be paired with several "satellite" females. Because this can result in severe fighting between females, it is best to remove the male and the dominant female from the community enclosure as soon as possible.

The procedures used in managing parent-reared cranes are somewhat different from those described above. Between the time that they are capable of flight and their removal from their parents, wing-brails are used to restrain flight. To prevent stiffening of the wrist joint, the brails are alternated from one wing to the other at about 2 week intervals. Chicks are removed from their parents when they are 6-10 months old, and are tranferred to large (13 x 33m) covered flight pens where they are maintained until their release or until pairing. We typically introduce birds into these flight pens simultaneously in order to minimize hostile interactions. As in the case of hand reared birds, parent reared birds become quite gregarious once a dominance hierarchy has been established.

CRANE REINTRODUCTIONS

Through research and experimentation, biologists have developed a number of manipulative techniques aimed at preserving and restoring populations of threatened and endangered species (Temple 1978a, Soule & Wilcox 1980). One such technique—the reintroduction of captive-bred stock—has found increasing acceptance as a means of augmenting and/or reestablishing wild populations. Captive-bred individuals have now been successfully returned to the wild in a variety of species of mammals, birds, and reptiles (Temple 1978b, Campbell 1980). Although many techniques for reintroducing cranes to the wild have been proposed (Hyde 1957, Erickson 1975, Konrad 1976), relatively few actual releases have been attempted thus far. In order to facilitate future experimentation, the various releases and reintroductions conducted to date are briefly summarized and reviewed below.

Translocations of wild birds

Nesbitt and Williams (1973) examined the dispersal and homing behavior of subadult Florida Sandhill Cranes by capturing wild birds and transplanting them from high population areas to other occupied areas suitable habitat. Between 1971 and 1973, 26 subadults were captured from nonbreeding flocks during the breeding season. In order to identify both year and location of the release, individuals were legbanded using standard metal bands and marked with either colored patagial streamers or colored plastic legbands. On the day following capture, the birds were released at locations approximately 37km or 95km from the capture sites. Subsequent observations revealed that the transplanted birds did not disperse widely, and did not attempt to home to the capture site.

These results suggest that translocations could be used in other sedentary (nonmigratory) crane species for restocking formerly occupied areas of suitable habitat, establishing completely new populations in secure areas, or augmenting declining populations after the identification of limiting factors. Successful restocking could presumably be accomplished with relatively few birds, since the use of wild birds would ensure high survivorship following release. Obviously, this technique deserves increased attention in the future.

Fostering and cross fostering of eggs

Since 1975 and 1976, respectively, Whooping Crane eggs from wild pairs in Wood Buffalo National Park (WBNP) and from captive pairs at Patuxent have been transferred to the nests of wild Greater Sandhill Cranes at Grays Lake National Wildlife Refuge (GLNWR) in southeastern Idaho in an attempt to establish an additional, self-sustaining population in North America. The foster-parent Sandhills are subsequently allowed to incubate, hatch, and rear the young Whooping Cranes. Details of this experiment have been summarized previously (Drewien & Bizeau 1978, Drewien & Kuyt 1979, Erickson & Derrickson 1981).

Before this cooperative project was initiated, considerable information had been gathered on the Sandhill Cranes at GLNWR and throughout the Rocky Mountain region. For example, between 1969 and 1974, over 700 cranes were captured and color-marked for investigations of nesting biology and seasonal movements (Drewien 1973, Drewien & Bizeau 1974). These studies revealed that pairs would tolerate considerable manipulation without deserting their nests, individual families showed regular seasonal movements, and young birds adopted the movement patterns of their parents. Additional factors favoring the Grays Lake population included: (1) GLNWR has one of the highest nesting densities of Sandhill Cranes in North America, (2) nesting success ranges from 78-92 percent annually,

(3) nesting chronology at GLNWR is similar to that of Whooping Cranes in WBNP, (4) birds in the GLNWR population show low levels of pesticide and heavy metal contamination, and (5) the birds spend considerable time on protected State and Federal refuges throughout the year. It should be noted that the high nesting density at GLNWR has facilitated close monitoring of the experiment, and has held logistical costs to reasonable levels.

The prospect for establishing a second population of Whooping Cranes through cross-fostering appears reasonably good, and field observations indicate that behavioral incompatibilities between Whooping Cranes and Sandhills will probably prevent mixed species pairing and hybridization. Unfortunately, the rate of increase in the cross-fostered population has been low due to adverse weather conditions at the time of hatching and chick rearing, coyote predation on chicks prior to fledging, subadults mortalities resulting from fence and powerline collisions, and the restricted number of eggs available for transplanting. Together these factors have resulted in a relatively small population with few individuals in each age class. At the present time, the lack of successful pairing and reproduction in the cross-fostered population appears to be due to the absence of females in the older age cohorts (R.C. Drewien, pers. comm.).

The probability of success in any reintroduction effort is largely dependent upon the rate of release. With the Grays Lake whooper population this can only be enhanced at this time by: (1) increasing predator control to minimize chick mortality; (2) increasing the number of eggs transplanted each year; and/or (3) directly augmenting the population through the release of captive reared stock. Although predator control has been intensified, we still have little control over the number of eggs available for cross-fostering. We can expect the number of eggs available from WBNP to increase slightly in the near future, but this will undoubtedly be a relatively slow process. Consequently, we are trying to increase the number of breeding pairs in captivity as rapidly as possible in order to increase the number of eggs available for transplanting each year. We do not envision attempting additional (see below) releases of captive birds until the size of the captive flock is substantially increased, and until release experimentation with Sandhill Cranes is completed.

The wild population of the endangered Mississippi Sandhill Crane currently numbers 40-50 birds, and is confined to a small area in Jackson County, Mississippi. As noted by Valentine (1981), there has been a progressive loss of breeding pairs in known nesting territories in recent years, and annual recruitment into the population continues to be extremely low. In an effort to maximize production of the remaining nesting pairs, infertile or addled eggs are now being routinely removed from wild nests and replaced with viable eggs produced by the captive flock at Patuxent. Although this fostering effort has only been underway for several years, it appears to be an effective method of enhancing the productivity of pairs that would otherwise be unable to hatch and rear young.

Direct releases to the wild

The first direct releases were primarily undertaken to assess whether or not cranes that were hand raised using conventional rearing methods could be returned to the wild. Although it was generally assumed that these birds would be unsuited for reintroduction, the possibility had to be tested since hand rearing represents the most economical method of raising large numbers of birds. Between 1971 and 1976, 18 Florida Sandhill Cranes raised at Patuxent were released into suitable habitat at several locations in Florida. Seventeen of these birds had been hand reared, while one bird had been raised by captive parents. All individuals were color marked and instrumented with radio transmitters before their release. The initial release involved 14 young birds (5-7 months old), and was carried out without either prerelease conditioning or supplemental feeding. None of the birds survived for more than 4 months. Particular problems noted during this experiment included: (1) tameness of the hand reared stock, (2) inability of the birds to forage adequately following release, (3) minimal association with wild birds, and (4) immaturity (Nesbitt 1979, S.A. Nesbitt, pers. comm.). Subsequent releases involved older birds and included supplemental feeding as a component of the reintroduction protocol. The 3 older hand raised birds survived considerably longer and associated with wild birds, but unfortunately never lost their affinity for humans. In contrast, the single parent reared bird (a female) rapidly assumed the behavior of wild birds, and survived to eventually pair with a wild male (Nesbitt 1979).

In recent years, several attempts have been made to release parent reared cranes into wild migratory populations. For example, a single subadult Greater Sandhill Crane was released in August 1976 at GLNWR in Idaho. This bird was parent reared at Patuxent, and was about 14 months old at the time of release. Following its release, this bird rapidly assumed the activity and foraging patterns typical of wild cranes, and adjusted well to wild conditions. Although the bird regularly foraged and roosted with wild Sandhills staging for migration, it never completely integrated with the wild flock and instead tended to follow groups and forage at the edges of the flock. This crane migrated from GLNWR in the company of wild birds on October 1, 1976, but was not relocated during migration or on the wintering grounds (R.C. Drewien, pers. comm.).

In order to test this procedure again, 11 additional captive parent-reared Sandhills were transported from Patuxent and released at GLNWR in mid-June 1980. All individuals (5 one year olds, 2 two year olds, and 4 three year olds) were released directly into the wild at GLNWR after being marked with colored leg bands and radio transmitters. Subsequent observations revealed that although the released cranes rapidly adopted activity patterns similar to wild birds, they spent significantly more time foraging and preening, and less time in vigilant behavior than their wild counterparts. The released cranes regularly associated with wild cranes, but associations developed in captivity, especially among the 2 and 3 year olds, appeared to slow integration into the wild flock. Seven of the released birds survived to migrate south in October; however, despite intensive ground and aerial searches only one bird was subsequently located on the wintering grounds. This bird, a female, was the only released crane that formed a discernible association with a wild individual. She was most recently observed in the spring of 1982 in Colorado, and was paired with a wild male at that time (Drewien et al. 1981, R.C. Drewien, pers. comm.).

These experimental releases have provided valuable information for designing future releases, and have demonstrated that: (1) birds that are hand raised using conventional procedures are generally unsuited for release into the wild; (2) 1-2 year old birds appear better able to make the transition from captivity to the wild and successfully integrate with wild conspecifics than birds that are either younger or older; and (3) captive birds are necessarily unfamiliar with wild conditions (i.e. food, predators, etc.) upon release, and consequently survivorship following release can be enhanced by using "soft release" procedures (i.e. prerelease conditioning, supplemental feeding, etc.). Such soft release procedures have similarly been shown to increase postrelease survivorship in a number of other species (cf. Temple 1978a, Ellis et al. 1978, Gatti 1981). All of these findings have been incorporated into the release program currently being conducted on the endangered Mississippi Sandhill Crane, and will be incorporated into future Greater Sandhill Crane releases in Idaho.

Indirect ("soft") releases to the wild

As previously mentioned, the remaining wild population of the Mississippi Sandhill Crane is restricted to a small area in southeastern Mississippi. The precarious status of this remnant population has resulted from a number of factors such as silviculture, urban and suburban growth, and highway construction which have together reduced or eliminated essential suitable habitat. Key components in the recovery effort for this endangered subspecies currently include land acquisition, habitat maintenance, habitat restoration, and captive propagation and reintroduction (Valentine 1981).

Captive propagation of this subspecies was initiated at Patuxent over a decade ago with the ultimate goal being to produce stock for augmenting the declining wild population, and reestablishing additional populations within the subspecies' former range. Beginning in

1979, propagation procedures were modified to enable the parent rearing of birds for release. Although eggs are still collected immediately after oviposition to maximize total production, they are placed under pairs of Florida or Greater Sandhill Cranes for incubation. These foster parents are allowed to complete incubation, and subsequently raise the young Mississippi chicks as their own. During the entire rearing period, human contact is avoided as much as possible. At approximately 60 days of age, the full-winged chicks are rendered flightless through the use of wing-brails, which are changed from one wing to the other at about 14 day intervals to prevent stiffness from developing in the wrist joints. At about 120 days of age, the brails are removed and the young birds are transferred to large, covered enclosures where they remain until being shipped to Mississippi. During this period the birds are preconditioned to accept corn in addition to their normal pelleted diet. Just prior to shipment, the birds are rebrailed and given complete medical examinations. Antihelminthic medications are administered to prevent the simultaneous transfer of parasites.

Once the birds arrive at the release site, they are individually marked with colored plastic leg bands and radio transmitters. Following this, they are released into a large enclosure which is located in natural habitat and contains feedsheds and feeders identical to those used at Patuxent. Corn is spread on the ground inside the enclosure to encourage natural foraging by the release birds and to attract wild birds to the area. Once the birds adjust to their new environment and are foraging primarily on natural foods (6-8 weeks), their wings brails are removed and they are allowed to leave the holding pen. All of these procedures are undertaken to "soften" the release and hasten acclimation to the new environment (Zwank & Derrickson 1982).

Three separate releases have been completed thus far; postrelease survivorship has varied each year as a result of minor modifications in release procedures. The first release (January 1981: 9 birds) resulted in high survivorship, but integration into the wild flock was apparently slowed by social bonding among the released cranes. Consequently, in order to minimize social bonding and encourage dispersal, birds raised at Patuxent the following year were allowed to remain with their parents until they were transferred to Mississippi. Although these birds dispersed rapidly as planned, survivorship during the second release (January 1982: 5 birds) was poor. Four of the 5 birds died within 2 months of release and the remaining bird was recaptured in an emaciated condition and returned to Patuxent. This particular bird showed head and bill injuries that probably resulted from fighting with another wild bird. We believe the poor survivorship that occurred in this release resulted primarily from the rapid dispersal, which increased the vulnerability of individuals to predators and accidents. Reduced flight capabilities resulting from prolonged wing-brailing may also have contributed to the vulnerability of these birds. Procedures used in the third release (October 1982: 7 birds) duplicated the procedures used in the first release, although the birds were released in late fall rather than midwinter to (1) reduce the time available for social bonding at Patuxent, and (2) time the release to the period of the year when wild birds are social and minimally aggressive toward conspecifics. To date, survivorship of these birds has been excellent. At the present time, 12 released birds survive (1981 release: 6, 1982 release: 6), and several of the older birds have successfully paired with wild mates.

Another interesting soft release technique is currently being used to reintroduce birds to a resident flock of Red-crowned Cranes at the Kushiro Crane Park in Japan. This program involves placing wing-clipped males in large breeding enclosures and allowing wild females to enter the open topped pens for pairing and nesting. Young birds that are successfully reared are allowed to fly from the pen with the female, and are subsequently integrated into the wild flock at winter feeding stations (Konrad 1976). This technique warrants additional attention in the future since many instances of wild birds pairing and successfully breeding with tame and/or captive birds have been documented (Sieber 1982, Hyde 1968, Longley 1970, Nesbitt 1979). As in the cross-fostering of eggs, chicks produced in this manner are parent reared, and the transition from captivity to the wild is gradual and supported by the parent. However, unlike either cross-fostering or other release techniques, this method can ony be used in localities where conspecifics are available for pairing, and requires extensive on site facilities to achieve a reasonable rate of release.

In June of 1981, a captive, 3 year old, parent reared female Whooping Crane was transferred from Patuxent to GLNWR and placed in a wild male's territory. This reintroduction was attempted in order to see if the currently male skewed sex ratio in the cross-fostered population could be rectified by establishing bonds between wild males and captive reared females. We assumed that the probabililty of pair-formation would be relatively high for several reasons, including: (1) dominance—in both wild and captive pairs, males are dominant to females in established breeding pairs. Because released birds are initially subordinate to wild birds following release, we believed that the female would show a similar response and this would hasten pairing; (2) age—the male at GLNWR was sexually mature, and the female was old enough for pairing; and (3) comparative information as indicated above, numerous cases have been documented where wild birds have successfully paired with tame or captive individuals. Previous release experiments with Sandhills had demonstrated that the transition period from captivity to the wild involved considerable learning, and consequently occurred over a relatively extended period. In the proposed release regime, we assumed that this transition period would be ameliorated and shortened to a great extent because the female would be introduced to available foods, foraging methods, roosting areas, and potential predators by her mate. Furthermore, because the male was raised in the wild, we assumed that pairing would ensure proper migration by the female. Unfortunately, although the female adjusted to the wild rapidly and associated with the male periodically, a firm pairbond was never established. Because successful migration by the female seemed unlikely, she was recaptured and returned to Patuxent in the fall. This experiment was repeated the following summer with similar results. Hopefully this method can be attempted again in the future on the wintering grounds rather than on the breeding grounds, since the absence of male territoriality at this time of year would increase potential association time, and since females would be able to interact with a number of different males, thereby minimizing potential incompatibility problems. In contrast to the aforementioned reintroduction program with the Red-crowned Cranes, this procedure would require minimal on-site facilities and would result in the release of captive raised birds. If this technique ultimately proves successful, we would simultaneously be able to augment the cross-fostered population, rectify the currently skewed sex ratio, and hasten the onset of breeding within the population.

Another soft release method used on hand-reared Sandhill Cranes has been previously described by Hyde (1957). Throughout their early development, chicks were raised with minimal human contact; after fledging they were allowed to fly from their enclosures and regularly associate with wild birds. Birds reared in this manner shunned humans and were accepted into the wild flock. During the transition from captivity to the wild, these birds were gradually exposed to natural food items, foraging techniques, and predators. Although it is not known whether these birds migrated successfully, excellent survivorship would be expected. This technique could eventually be used to introduce hand raised birds into both migratory and nonmigratory populations.

Even though relatively few releases have been conducted to date, it is already clear that a number of factors must be addressed whenever planning and conducting releases. Such factors include: (1) characteristics of the reintroduction site; (2) biological characteristics of the wild population (i.e. migratory vs. nonmigratory, typical vs. atypical demography, traditions, etc.); (3) number of individuals available for reintroduction; (4) methods of captive rearing; (5) age of birds at release; (6) timeing of the reintroduction; (7) methods of preconditioning; (8) methods of enhancing postrelease survivorship; and (9) methods of monitoring results. Although the development of reliable methods for reintroducing cranes has proven to be a relatively difficult task, considerable progress has already been made. This challenging research effort needs to be accelerated and expanded, however, if captive propagation is to fulfill one of its principal goals — the preservation of endangered populations in the wild. In the future, captive propagation and planned reintroduction will undoubtedly play an increasing role in the conservation and management of our endangered cranes.

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A PROPOSED MANAGEMENT PLAN FOR CAPTIVE RED-CROWNED CRANES

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ABSTRACT

This paper discusses the captive population of the Red-crowned Crane (*Grus japonensis*), an endangered species, and proposes measures to increase its genetic diversity and minimize inbreeding. There were 113 captive Red-crowned Cranes listed in the 1981 studbook. These comprised 53 unrelated lines, 28 of which had bred in captivity. The population grew 7% to 8% annually from 1975 to 1980. Its genetic diversity is low because a few breeding pairs have flooded the population with their offspring. Seven of the 25 pairs are inbreeding. A management plan is necessary to improve the population's value as a gene bank for a future restocking effort. The measures I propose are: 1. Prevent overproductive pairs from further breeding; 2. Prevent some of the offspring of overproductive pairs from breeding; 3. Breed stocks that have not bred in captivity; 4. A mating scheme to minimize inbreeding; and 5. A demographic plan to coordinate these measures. Such a plan would require the long-term, international, cooperation of zoos and breeding centers and necessitates the exchange of certain cranes between these institutions.

INTRODUCTION

The Red-crowned Crane (*Grus japonensis*) is an endangered species whose captive population is growing rapidly enough to make restocking feasible when its habitat becomes sufficiently protected. Institutions that breed Red-crowned Cranes should strive to maintain as much genetic variability in the captive population to minimize the harmful effects of genetic drift and inbreeding that often occur in small populations. The genetic variance of captive Red-crowned Cranes is much lower than it would be if the proper management measures were applied; the risk of inbreeding is increasing because of the growing number of related, captive bred, birds. A management plan based on population genetics would improve the genetic value of the population and increase the probability that a restocking program would be successful.

THE CAPTIVE POPULATION OF RED-CROWNED CRANES

The population I am considering is those birds registered in the latest Red-crowned Crane studbook (Asakura and Ito 1981), but I have included more recent information on some cranes and corrected several errors in the studbook. None of the Red-crowned Cranes in Chinese zoos are registered, so I have excluded them.

There were 113(51.54.8) registered Red-crowned Cranes in captivity on 1 Jan. 1981. The population has a maximum of 53 (25.28) unrelated lines, but, since the genealogies of most lines are incomplete or missing, some of the lines are probably related. Twenty eight (11.17) lines had living offspring at the beginning of 1981.

The most recent generation of captive bred Red-crowned Cranes includes about 63 young. Thirty four of these were produced by the 3 most productive males and 33 are the offspring of only 4 females. Thus, about half of the offspring have been produced by only 1/8 of the male stocks and 1/7 of the female stocks, creating a very unequal distribution of offspring among the founders.

Eighty seven of the 113 birds have close relatives (parents, siblings, or offspring) in the population. Most of the remaining 26 came from Chinese zoos or were wild caught, so nothing is known of their genealogies. Inbreeding is becoming increasingly difficult to avoid as more chicks hatch. Some institutions have several interrelated individuals and few unrelated ones with which to pair them.

Seven of the 25 breeding pairs are of related birds. Five of these would have offspring with a coefficient of inbreeding, f, of .25 and two would have progeny with an f of .125. An f of .25 is the equivalent to a brother-sister or parent-offspring mating. The International Crane Foundation (ICF) split a half-sib pair in 1982 in order to prevent them from inbreeding. Four Red-crowned Cranes are known to be inbred as a result of captive breeding. They have f's of .125 to .3125.

In the period 1975-1980 the captive population of Red-crowned Cranes had a natural growth rate of 7%-8% per year. The number of hatches has increased each year since 1973, except in 1979, and hatches outnumbered deatbs in every year after 1974. This accelerating growtb rate will eventually produce surplus birds and leaves room for manipulating the population to increase its value for restocking.

New stocks of Red-crowned Cranes have recently come into the population from two sources: cranes preserved from the wild, especially at Kushiro, and birds exported from China. Kushiro Crane Park had released, or had escape, 11 of its Red-crowned Cranes by 1980. At least 7 of these birds were captive bred. Kushiro is a good place to test the success of different methods of rearing and releasing cranes, because cranes are strictly protected in Japan. The wild population on Hokkaido is nonmigratory to slightly migratory and numbered 271 in 1979 (Koga 1981).

The other populations are much less well known than the Hokkaido one. Ma (1981) estimates that more than 1000 breed in China. Approximately 200 Red-crowned Cranes live in the Southeastern Soviet Union (Shibaev and Gluschchenko 1982), especially around Lake Khanka and in the Amur River Region (Masatomi 1974, Viniter 1977, Won 1981). Some Red-crowned Cranes winter in Korea and a few may breed there (Archibald 1981, Won 1981).

THE OBJECTIVES OF CAPTIVE MANAGEMENT

In order to slow evolution in a captive population it is necessary to maintain a high level of genetic variability in the animals and minimize inbreeding (Franklin 1980). Denniston (1977) shows the degree to which genetic variability decreases over time in small populations of constant size and the same principles apply to the slowly growing population of captive Red-crowned Cranes. This loss of genetic diversity is accelerated by a decrease in the effective population size (or variance effective number), Ne. By making the Ne of the population larger, we can slow the loss of genetic variability considerably.

Inbreeding increases homozygosity, which almost always lowers fitness in natural populations and decreases fecundity in captive ones (Soule' 1980). Some endangered species of waterfowl have depressed male fertility when they are inbred (Berger 1977, Kear 1977) while other species seem to have been unaffected by extreme inbreeding (Kear 1977, Lovejoy 1977). Greenwell et al. (1982) found that the fertility and hatchability of the eggs, and survivorship of the chicks, of Mandarin Ducks (*Aix galericulata*) increased significantly after the inbred females mated with some unrelated males. The different responses of waterfowl to inbreeding demonstrate that one cannot safely predict whether a rare species of bird will survive high levels of inbreeding in captivity; therefore, we should avoid inbreeding whenever a captive population is large enough to do so.

Koga (1976) says that the fertility of Red-crowned Crane eggs at the Tokyo Ueno Zoo was low after the flock there was reduced to one pair due to food shortages during World War II. These birds may have been related, since the Ueno Zoo had bred Red-crowned Cranes previously. The male (studbook #18-01) of this pair has more descendants than any other registered Red-crowned Crane and several of his descendants may be inbred. One goal of captive management must be to identify inbred subpopulations and to outbreed those birds.

Another goal of propagation is to increase the number of Red-crowned Cranes in captivity. However, this increase should be controlled so that it does not cause more inbreeding later.

SUGGESTIONS FOR MANAGING CAPTIVE RED-CROWNED CRANES

The effective population number, Ne, is the size of an ideal population that has the same amount of genetic drift as the population under consideration. An ideal population has a constant size, random mating, 2.0 offspring per pair, and a binomial distribution of offspring among the pairs (Crow & Kimura 1970).

A simplified equation for the effective population number is

$$Ne = \frac{N\bar{k}}{\left(\left(\frac{N}{N-1}\right)\left(\frac{N\bar{k}}{\bar{k}}\right)(l+f)\right)+i-f},$$

where N is the size of the parent population, $\bar{k}$ is the mean number of offspring per pair, and f is the coefficient of inbreeding in the parent population (Denniston 1977).

Therefore, we need to breed more pairs of Red-crowned Cranes, increase the number of offspring per pair, and equalize the number of offspring per pair. F has a small effect on Ne except when f is large or when the number of offspring per pair is less than one; however, I have already stated that we should minimize f for other reasons.

Since we are already trying to enlarge N and $\bar{k}$ by producing more chicks and then breeding them, the easiest way to increase Ne is by decreasing Vk by promoting a uniform number of offspring among the pairs.

Based on this model, I propose the following management plan for captive Red-crowned Cranes:

1. Prevent good breeding pairs from producing too many offspring.
2. Prevent some of the offspring of overproductive pairs from mating.
3. Try to breed the stocks that have not yet bred in captivity.
4. Develop a mating scheme for all the breeding birds to minimize inbreeding.
5. Coordinate these measures with a long range demographic plan that defines the maximum number of Red-crowned Cranes that can be kept in captivity, the optimum number of offspring per pair, and related parameters.

These management measures are similar to those suggested by Foose (1982b) and might be administered much like the AAZPA's Species Survival Plans, except on an intercontinental scale. Conway (1982) and Foose (1982a) describe the purposes and operation of the Species Survival Plans. The White-naped Crane (*Grus vipio*) is one of a handful of birds for which a Species Survival Plan is being developed. Dr. Sheppard of the Bronx Zoo, the studbook keeper for White-naped Cranes, is the species coordinator for this project (Schmitt 1982). Schmitt (1982) suggests that the White-naped Crane SSP could be a model for the management of other cranes.

The first two measures of this plan would increase the genetic diversity among captive Red-crowned Cranes by decreasing the variance in the number of offspring per pair. *Table 1* shows the degree to which the distribution of offspring among the pairs affects Ne. It compares the Ne of three hypothetical populations, each of which has 25 breeding pairs

(N=50), 65 offspring ($\bar{k}$=65/25=2.6), and an f of .01 in the parent generation. Population A has a few pairs that produced most of the offspring. It is a slightly optimistic model of the captive Red-crowned Crane population but is *not* an attempt to calculate Ne for the real population. Population B has the closest possible fit to the Poisson Distribution of offspring numbers. Population C has the lowest Vk possible under the conditions; all pairs have either 2 or 3 offspring.

Table 1 shows that Population A, with its high Vk, has an effective population size less than half that of Population B and about one-fourth that of Population C.

Preventing some of the progeny of overproductive pairs from mating, or culling, as suggested by Denniston (1977), can reverse part of the adverse effects of having a few especially fecund pairs in a population. Although cullng lowers the k of the population, it could increase the effective population number of Population A by nearly 50% and requires little effort.

The best culling method is to cull offspring from the most productive pair until their number is equal to that of the second most productive pair, and so on. For Population A, for example, this would result in the most productive pairs having only 2 or 3 offspring in the breeding population instead of 10, 9, 8, 6, 5, 5, 4, 4, and 4 respectively. I do not know how many offspring a pair must have in order to be "overproductive." A demographic plan can determine this number. The key thing is to aim for an equal number of offspring for all the pairs.

With good planning, culling could be kept to a minimum after it has been done once. The non-breeding birds could be loaned to zoos that wish to display Red-crowned Cranes but do not wish to breed them. Extra progeny, or eggs, could be used for restocking and cross-fostering experiments or for behavioral research.

Breeding the stocks of Red-crowned Cranes that have not yet bred in captivity would enlarge the size of the sample (N) from which the next generation draws its genetic material. The 25 stocks that had not bred by 1980 represent nearly half of the possibly unrelated lines in the population. Also, Red-crowned Cranes that are preserved from the wild and kept in captivity because of injuries should be bred. Artificial insemination can make some injured cranes productive breeders.

Any small, closed population will become inbred given enough generations, so inbreeding is inevitable in captive propagation. The proposals I have made would lessen the probability that a randomly chosen pair of birds is related. However, zoos do not choose pairs randomly, but from the birds that are available.

We need to establish a mating scheme that minimizes inbreeding for captive Red-crowned Cranes. This would require the cooperation of all the breeding centers involved. Flesness (1977) and Senner (1980) give mating schemes for maximum avoidance of inbreeding in small, stable, populations where all of the founders are unrelated. The captive population of Red-crowned Cranes is much more complex, but the principles of the mating scheme for it are the same.

Table 2 shows the coefficients of inbreeding, f, for all possible matings of Red-crowned Cranes that are shown to be related by the studbook (Asakura & Ito 1981). Each crane appears only in a matrix with its relatives; individuals from different matrices can be assumed to be unrelated.

Table 3 is a list of captive Red-crowned Cranes that have no relatives in the population. These individuals are genetically valuable and should be bred if possible.

Table 4 is a sample mating scheme for Red-crowned Cranes drawn from the data in *Tables 2* and *3* and from the studbook (Asakura & Ito 1981). The criteria I used to form the pairs include the birds' degree of relatedness, their locations, their ages, and the number of offspring and siblings that the cranes have.

The latter part of *Table 4* lists the breeding age individuals that should not be bred and the reason for not breeding them, and the ages and locations of those cranes whose sexes are not listed in the studbook (Asakura & Ito 1981). Preventing a productive crane from breeding may be the most difficult part of this plan to accept, but not breeding certain

Table 1. Effective population number, Ne, of three hypothetical populations, each of which has 25 breeding pairs, 65 offspring, and an f of .01. The offspring are distributed among the pairs in each population as follows:

Population A: 10, 9, 8, 6, 5, 4, 4, 4, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 0, 0.
Population B: 7, 5, 5, 4, 4, 4, 4, 3, 3, 3, 3, 3, 2, 2, 2, 2, 2, 2, 1, 1, 1, 1, 1, 0, 0.
Population C: 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2.

Population	$\bar{k}$	Vk	Ne
A	2.60	8.50	29.82
B	2.60	2.83	61.52
C	2.60	0.25	119.36

Table 2. Coefficient of inbreeding, f, for all possible matings of related, captive Red-crowned Cranes; and, locations and mates of captive Red-crowned Cranes as of 1 Jan 1981. Most raw data from Asakura and Ito, 1981.

	Females			Sex Unknown					Remarks
Males	3-01	3-05	3-07	3-10	3-11	3-13	3-14	3-15	All birds at Carl Hagenbecks Zoo, Hamburg, except 3-05 and 3-06. Pairs: 3-06/3-05 (f=.25) at Munich, 3-09/3-07 (f=.25). 11-01 died in 1981.
3-03	.25	.25	.25	.25	.25	.25	.25	.25	
3-06	.25	.25	.25	.25	.25	.25	.25	.25	
3-09	.25	.25	.25	.25	.25	.25	.25	.25	
11-01	0	.25	.25	.25	.25	.25	.25	.25	
Sex Unknown									
3-10	.25	.25	.25	X	.25	.25	.25	.25	
3-11	.25	.25	.25	.25	X	.25	.25	.25	
3-13	.25	.25	.25	.25	.25	X	.25	.25	
3-14	.25	.25	.25	.25	.25	.25	X	.25	
3-15	.25	.25	.25	.25	.25	.25	.25	X	

Male	Female 6-02	Remarks
6-01	.25	Mother-son pair at Frankfurt.

	Females				Remarks
Males	9-06	9-29	9-37	9-49	All are at Kushiro Crane Park. Pairs: 9-37/9-41, 9-42/9-40 (f=0).
9-05	0	.25	.25	.25	
9-42	.25	.25	.25	.25	

	Females			Remarks
Male	9-17	9-29	9-44	All are at Kushiro Crane Park. Pair: 9-01/9-17 (f=0).
9-01	0	.25	.25	

	Females				Sex Unknown		Remarks
Males	8-01	9-04	9-35	9-40	8-03	8-04	8-01, 8-03, 8-04, and 9-14 are at Korakuen, Okayama. 9-04, 9-26, 9-35, 9-40, and 9-41
9-14	0	.25	.25	.25	.25	.25	
9-26	0	.25	.25	.25	.125	.125	
9-41	0	.25	.25	.25	.125	.125	

Table 2. (cont.)

	Females				Sex Unknown		Remarks
Sex Unknown							are at Kushiro C.P. Pairs: 8-01/9-14, 9-04/9-55, 9-26/9-29, 9-42/9-40, 9-41/0-37 (f=0).
8-03	.25	.125	.125	.125	X	.25	
8-04	.25	.125	.125	.125	.25	X	

	Females			Sex Unknown	Remarks
Males	16-03	21-02	21-07	21-08	16-02, 21-02, 21-05, 21-07, and 21-08 are at Whipsnade; 16-03 and 21-04-2 are at Rotterdam; 16-05 is at West Berlin Pairs: 16-02/21-02, 21-03/16-03 (f=0), and 21-05/21-07 (f=.25).
16-02	.25	0	.25	.25	
16-05	.25	0	.125	.125	
21-04-2	.125	.25	.25	.25	

	Females								
Males	18-03	18-05	18-06 18-07	18-11	20-06 20-08	28-03 28-05 28-13	28-34	28-37	23-02
18-02	.1875	0	.2813	.0938	.3125	.1563	.1563	.2344	0
18-04	0	0	0	.25	0	0	0	0	0
18-08	.0938	.25	.2813	.4688	.1563	.0781	.0781	.1172	0
18-10	.0938	.25	.2813	.4688	.1563	.0781	.0781	.1172	0
20-02	.125	0	.1563	.0625	.1875	.25	.25	.375	0
28-02	0	0	0	0	0	.125	0	.0625	0
28-10	.0625	0	.0781	.0313	.0938	.25	.125	.25	0
28-11	.0625	0	.0781	.0313	.0938	.25	.125	.25	0
28-16	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-20	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-23	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-25	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-26	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-31	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-32	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0
28-33	.0625	0	.0781	.0313	.0938	.125	.25	.1875	0

Remarks: 18-02, 18-03, 18-04, 18-05, 18-06, and 18-07 at Tokyo Tama; 18-08 and 18-11 at Inogashira; 18-10, 20-06, and 20-10 at Tokyo Ueno; 28-02 at San Diego (1982); 28-31, 28-32, and 28-33 at Vogelpark Walsrode; 28-26 at Washington NZP; all others at ICF. 20-06 and 20-08 have f of .3125, 18-02 has f of .125, and 28-37 has f of .25. Pairs: 18-02/18-05, 18-04/18-03, 28-02/23-02 and 28-34, 28-08/28-13 (f=0 for all), and 28-23/28-05 (f=.125). 28-16 and 28-20 died in 1981.

	Females		Remarks
Male	27-03	27-04	All at Kyoto. Pairs: 27-02/27-04 (f=.25), 27-01/27-03 and 27-04, 27-02/27-03 (f=0 for all).
27-02	0	.25	

	Females		Remarks
Males	30-02	30-04	All at Kobe Oji Zoo. Pair: 30-01/30-02 (f=0).
30-01	0	.25	
30-03	.25	.25	

Table 3. List of registered Red-crowned Cranes that are not known to have any captive relatives. Adapted from Asakura and Ito, 1981.

Males	Location and Mate	Females	Location and Mate
4-01	Seoul; 4-03	4-03	Seoul; 4-01
9-55	Kushiro C.P.; 9-04	4-05	Seoul
20-09	Tokyo Ueno; 20-10	3-02	Munich; died 1981
21-03	Rotterdam; 16-03	20-10	Tokyo Ueno; 20-09
22-02	Higashiyama Zoo, Nagoya	22-03	Higashiyama Zoo, Nagoya
25-03	East Berlin; 25-04	25-04	East Berlin; 25-03
27-01	Kyoto; 27-03, 27-04	29-02	Ayamegaike Zoo, Nara
28-08	ICF; 28-13	33-02	Yokohama
29-01	Ayamegaike Zoo, Nara	35-02	Kushiro Zoo; 35-01
32-01	Rangoon	36-01	Misaki Zoo, Osaka
35-01	Kushiro Zoo; 35-02	36-02	Misaki Zoo, Osaka
36-03	Misaki Zoo, Osaka		
37-01	San Diego; died 1983		
33-01	Yokohama; died 1981		

Table 4. Sample mating scheme to minimize inbreeding in captive Red-crowned Cranes. Studbook nos. and locations are from Asakura and Ito, 1981, except where noted.

Pair (M/F)	Location 1 Jan 1981 (M/F)	Comments
3-03/6-02	Hagenbecks/Frankfurt	Split 6-01/6-02, transfer
3-06/9-49	Munich/Kurshiro C.P.	Split 3-06/3-05, transfer
3-09/19-07	Hagenbecks/Osaka Ten-noji	Split 3-09/3-07, transfer
4-01/4-03	Seoul	Already paired
6-01/3-05	Frankfurt/Munich	Split 6-01/6-02, 3-06/3-05
9-01/9-17	Kushiro C.P.	Already paired
9-05/9-06	Kushiro C.P.	Already paired
9-14/8-01	Korakuen	Already paired
9-26/9-29	Kushiro C.P.	Already paired
9-41/9-37	Kushiro C.P.	Already paired
9-42/9-40	Kushrio C.P.	Already paired
9-55/9-35	Kushiro C.P.	Split 9-55/9-04
16-02/21-02	Whipsnade	Already paired
16-05/18-07	West Berlin/Tokyo Tama	Requires transfer
18-02/18-05	Tokyo Tama	Already paired
18-04/18-03	Tokyo Tama	Already paired
18-08/9-20	Inogashira/Kushiro C.P.	Requires transfer
18-10/33-02	Tokyo Ueno/Yokohama	Requires transfer
19-05/18-11	Osaka Ten-noji/Inogashira	Requires transfer
19-06/18-06	Osaka Ten-noji/Tokya Tama	Requires transfer
19-09/30-04	Osaka Ten-noji/Kobe Oji	Requires transfer
20-09/20-10	Tokyo Ueno	Already paired
21-03/16-03	Rotterdam	Already paired
21-04-2/19-04	Whipsnade/Osaka Ten-noji	Requires transfer
21-05/36-02	Whipsnade/Osaka Misaki	Split 21-05/21-07, transfer
22-02/22-03	Nagoya Higashiyama	Already paired
25-03/25-04	East Berlin	Already paired
27-01/27-04	Kyoto	Already paired
27-02/27-03	Kyoto	Already paired
28-02/28-34	ICF	Already paired
28-23/SD-3	ICF/San Diego	Split 28-23/28-05, note 1
28-26/USNZ-2	ICF/Front Royal	See notes 1 and 2
28-31/3-07	Walsrode/Hagenbecks	Split 3-09/3-07, note 4
28-32/21-07	Walsrode/Whipsnade	Split 21-05/21-07, note 4

Table 4 (cont.)

Pair (M/F)	Location 1 Jan 1981 (M/F)	Comments
28-33/9-44	Walsrode/Kushiro C.P.	Requires transfer, note 4
29-01/29-02	Nara Ayamegaike	Form pair
30-01/30-02	Kobe Oji	Already paired
32-01/4-05	Rangoon/Seoul	Requires transfer
35-01/35-02	Kushiro Zoo	Already paired
36-03/36-01	Osaka Misaki	Already paired
SD-4/28-03	San Diego	See notes 1 and 3
SD-5/37-02	San Diego	See note 1

Notes: 1) San Diego acquired 2.2 Red-crowned Cranes in 1981, 1.1 from Osaka Ten-noji and 1.1 from China, and transferred 0.1 to Front Royal. I do not know their studbook numbers. 2) 28-26 is not dead, as was reported in the 1981 studbook. 3) 28-03 was transferred to San Diego in 1982. 4) 28-31, 28-32, and 28-33 were transferred to Walsrode in 1983.

Table 4 (cont.) Red-crowned Cranes of known sex that should not be bred.

Studbook No.	Sex	Location	Reason
3-01	F	Hagenbecks	Too many offspring
9-04	F	Kushiro C.P.	Too many offspring
19-01	M	Osaka Ten-noji	Too many offspring
19-03	F	Osaka Ten-noji	Too many offspring
19-10	F	Osaka Ten-noji	Too many siblings
19-12	F	Osaka Ten-noji	Too many siblings
20-02	M	ICF	Too many offspring
20-06	F	Tokyo Ueno	Inbred, f=.3125
20-08	F	Tokyo Ueno	Inbred, f=.3125
23-02	F	ICF	Too many offspring
28-08	M	ICF	Crane *Herpes* virus
28-10	M	ICF	Crane *Herpes* virus
28-11	M	ICF	Crane *Herpes* virus
28-13	F	ICF	Crane *Herpes* virus
28-25	M	ICF	Blind from birth
28-37	F	ICF	Too many siblings

Unsexed, registered, Red-crowned Cranes. From Asakura and Ito, 1981.

Studbook No.	Location	Year hatched	Comments
3-10	Hagenbecks	1975	Should not be bred
3-11	Hagenbecks	1977	Should not be bred
3-13	Hagenbecks	1978	Should not be bred
3-14	Hagenbecks	1979	Should not be bred
3-15	Hagenbecks	1980	Should not be bred
8-03	Korakuen	1979	Should be bred
8-04	Korakuen	1980	Should be bred
21-08	Whipsnade	1980	Should be bred

birds would significantly improve the genetic diversity of the population.

Some geneticists (e.g. Foose 1982b) advocate dividing captive populations into demes. The three logical demes of captive Red-crowned Cranes—those in Japan, Europe, and in the United States—have too many related Red-crowned Cranes within them for the deme idea to work well. I believe the population should be managed as a whole.

There are many other ways in which to pair captive Red-crowned Cranes to minimize inbreeding for one generation, but once a scheme is established it should be continued. Such a mating scheme becomes more prescribed with each successive generation. It also becomes more complicated so there is no point in working out a second generation mating scheme until the Red-crowned Crane breeding centers agree on a management plan.

The population of captive Red-crowned Cranes may eventually outgrow the space available for it. Demographic planning can prevent this from happening. For example, each breeding center could decide how many Red-crowned Cranes it can accommodate and the centers could shuffle the birds around when a center exceeded its capacity. However, by agreeing on an optimum number of offspring to maintain a stable population size near the carrying capacity we could avoid overcrowding while still maximizing the population's genetic diversity. Each pair could be bred until it reached the target number of offspring. We could use this number to decide which Red-crowned Cranes have been overproductive, and take appropriate action. See Foose (1977) for a good discussion of demographic aspects of captive breeding programs.

The cooperation of private aviculturists might increase the carrying capacity of captive bird populations (Conway 1977). Satellite breeding centers, such as the New York Zoological Society's St. Catherine's Island, Georgia, and the National Zoological Park's breeding center at Front Royal, Virginia, are well suited for off-exhibit breeding of endangered species, including cranes (Doherty 1982). It is hoped zoos that have breeding centers will expand their crane propagation programs.

This management plan would require the transfer of many Red-crowned Cranes, but it is necessary because of the way in which the birds are interrelated. Cryogenic preservation of crane semen, if it were perfected, would make transfers unnecessary, because semen from the correct male could be shipped to another location to inseminate a female (Russman 1983).

Institutions that breed Red-crowned Cranes need to communicate with one another more in order to set up exchanges of birds. Each should obtain a copy of the *World Register of Red-crowned Cranes* (Asakura & Ito 1981) so as to be adequately informed on the locations and genealogies of the registered Red-crowned Cranes. A lack of communication between beeding centers would lead to a haphazard approach to Red-crowned Crane propagation. Red-crowned Crane breeding would be much more beneficial to the species if we had a definite, cooperative, management plan. *Table 2* in this paper is a useful guide for finding unrelated mates for Red-crowned Cranes that are not paired or are breeding with relatives.

SUMMARY

The captive population of Red-crowned Cranes is growing, but in an unplanned manner. The goal of breeding any endangered species should be to insure that the captive population remains genetically healthy until a sufficient part of its habitat is protected to make restocking feasible. I propose a captive management plan for Red-crowned Cranes that would minimize inbreeding and increase the genetic variability of the captive population. The main point of the plan is a prescribed mating scheme that minimizes inbreeding, which is an increasing problem among captive Red-crowned Cranes. The remainder of the plan would increase the effective population size by promoting an equal number of descendants for each unrelated line and by breeding lines of Red-crowned Cranes that have not yet bred in captivity. These measures would all be coordinated with a demographic plan. Such a management plan would require the transfer of many Red-crowned Cranes and can only work with the long term cooperation of the breeding centers involved.

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SEMEN VOLUMES AND PEAK PRODUCTION PERIODS FOR CRANES AT THE INTERNATIONAL CRANE FOUNDATION

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ABSTRACT

Volumes of uncontaminated semen samples collected from cranes at the ICF from 1977 to 1982 varied from less than 0.01ml to greater than 0.3ml. Mean annual semen volume appeared to increase through the period. Mean volume and semen quality varied considerably among the individual birds. There was a significant correlation between annual mean semen volume and semen quality. Siberian Crane semen samples were of lower quality than White-naped or Red-crowned semen samples. The period of semen production varied from 30 to 148 days, beginning in late February or early March for northern latitude species. Duration of peak production varied from zero or one day to 139 days.

INTRODUCTION

The captive maintenance of small breeding populations is one means of ensuring the survival of endangered species (Martin 1975). Although natural pairing and copulation is the preferable way to obtain fertile eggs, this is frequently impossible or impractical (Gee & Temple 1978). Artificial insemination (AI) is commonly recognized as a useful tool in dealing with many of the infertility problems in captive birds.

Artificial insemination techniques have been used in poultry for decades (Quinn & Burrows 1936). The use of AI with nondomestic birds has been more recent, but has been applied to geese (Johnson 1954, Oliver 1971), pheasants (Manu et al. 1966), raptors (Berry 1972, Grier 1973, and Bird et al. 1976), cranes (Gee 1969, Archibald 1974, and LaRue 1981) and others.

Some of the variables that may affect fertility rates of artificially inseminated captive birds include semen volume, semen quality, and duration of semen production. This paper summarizes some of the results obtained from semen collections as part of the captive propagation program at The International Crane Foundation (ICF) from 1977 to 1982.

METHODS

Semen was collected using the massage technique first developed for poultry (Quinn & Burrows 1936). AI techniques developed for cranes at the Patuxent Wildlife Research Center by Gee (1969) were adopted by ICF (Russman 1979, LaRue 1981).

Semen volume was measured in a 1.00cc tuberculin syringe. The semen quality was rated according to a five-grade scale (A, B, C, D, F) developed by Russman (1979). An A-quality semen sample was judged to be of "high quality," and was used as an indicator of peak production.

Mean semen volumes, semen quality, and duration of production were compared for the different years, between selected individuals, and between species. Correlation of mean annual semen volume and quality data were analyzed using the Spearman rank correlation coefficient (Steel & Torrie 1960, Kraft & Van Eeden 1968).

RESULTS

Analysis of a sample (N=107) of means of yearly semen collections yielded a mean of 0.07ml, a standard deviation of 0.058ml, and a range of 0.26ml.

Annual semen production values are presented in *Table 1*. An unsuccessful collection is one where the bird is uncooperative or no sample was obtained. A usable sample excludes badly contaminated samples. The latter might have biased volume values and have been found to be detrimental to sperm (Lake 1956, Smyth 1968, Boone & Hughes 1970, Skinner 1974). The mean semen volume and the percent A-quality was based on usable samples. The large number of collections in 1981 was due to a research project on crane sperm morphology (Russman 1981). The percent of collections that were successful was similar throughout the period, except for 1981. The lower percentage that year may be partly explained by the large number of birds that were sampled only that year. The percent of collection attempts that were usable varied more. Although mean semen volume appeared to increase from 1977 to 1982, there was no readily identifiable trend in A-quality samples during the period.

The mean annual semen volume varied among the cranes most frequently sampled (*Fig. 1*). The suggestion that mean volume decreases with time in captivity (Baumann 1981) does not appear to be supported by these data, although that may be so in some individual cases. Some individuals gave increasingly larger samples, while others showed no identifiable trend.

The semen quality (the percentage of usable semen collections in a season that were of A-quality) varied considerably among the individual cranes (*Fig. 2*). Semen quality among the highly productive males remained relatively stable. Both increases and decreases were observed.

There was a significant correlation between annual mean semen volume and semen quality, using the Spearman rank coefficient as an indicator of correlation between the two variables (*Fig. 3*). Each point in *Fig. 3* represents the pairing of the mean semen volume and the percent of collections of A-quality of an individual for a particular season.

Individual cranes showed variable relationships between semen volume and quality (*Figs. 1, 2*). Watson, a Wattled Crane (*Bugeranus carunculatus*), showed a fairly close correlation between volume and quality. The mean volume of samples collected from Tsuru, a Red-crowned Crane (*Grus japonensis*), is similar, but quality was high in 1980 and zero in 1978 and 1981. There was an inverse relationship between variables for Painless, an Eastern Sarus Crane (*G. antigone sharpii*). Another Eastern Sarus, Squirt, showed peak production to coincide with peak quality (1980). There appeared to be a good positive relationship between the two variables, both decreasing, in samples from Willie, a Brolga (*G. rubicundus*). Samples from Tilliman, a Siberian Crane (*B. leucogeranus*), showed a greater than twofold increase in quantity in 1981, but there was a large decrease in quality for the same period.

Mean semen volume (*Fig. 4*) and semen quality (*Fig. 5*) appeared to vary between the three crane species most frequently sampled from at the ICF. The White-naped Crane (*G. vipio*) sampled had a higher mean semen volume. Siberian Crane semen was consistently of lower quality than the White-naped or Red-crowned Crane samples.

Duration of semen production (first date a successful sample was obtained to last date of season a successful sample was obtained) and peak production (first date a sample of A-quality was collected to the last date of season when an A-quality sample was collected)

Table 1. Semen production of cranes at ICF, 1977-1982.

Year	Number of cranes worked	Number of times worked	Number (%) successful	Number (%) usable	Number (%) A-quality(a)	Mean semen volume (ml) ±SD
1977	6	150	123 (82)	107 (71)	47 (44)	0.13 ± 0.098
1978	17	402	352 (88)	201 (50)	105 (52)	0.11 ± 0.097
1979	10	388	335 (86)	289 (74)	137 (47)	0.12 ± 0.096
1980	14	484	427 (88)	420 (87)	246 (58)	0.06 ± 0.083
1981	41	1509	1003 (66)	977 (65)	172 (18)	0.05 ± 0.060
1982	12	294	252 (86)	248 (84)	73 (29)	0.07 ± 0.076
Total		3227	2492 (77)	2242 (69)	780 (35)	0.07

(a) percentage of usable samples

Table 2. Mean number of successful semen collections and mean A days of some cranes at ICF.

	Species	Number of years sampled	Total days sampled	Mean days sampled	Years 'A'	Total A days	Mean A days
Ueno	G.j.	6	267	44 ± 12.9	6	155	26 ± 15.2
Casey	G.v.	6	253	42 ± 9.1	6	150	25 ± 12.5
Wolf	G.l.	6	144	24 ± 8.6	5	12	2 ± 1.5
Butch	G.v.	5	150	30 ± 22.3	5	79	16 ± 7.9
Watson	Bu. c.	5	106	21 ± 6.6	5	47	9 ± 3.5
Painless	G. an.	4	166	42 ± 10.2	3	53	18 ± 14.4
Tony	G. am.	4	113	28 ± 7.3	2	5	2 ± 0.7
Squirt	G. an.	4	101	25 ± 16.7	1	8	8 ——
Killer	A.p.	4	98	24 ± 3.8	3	23	8 ± 6.4
Tilliman	G.l.	3	113	38 ± 3.0	3	29	12 ± 11.7
Tsuru	G.j.	3	46	15 ± 20.2	1	28	28

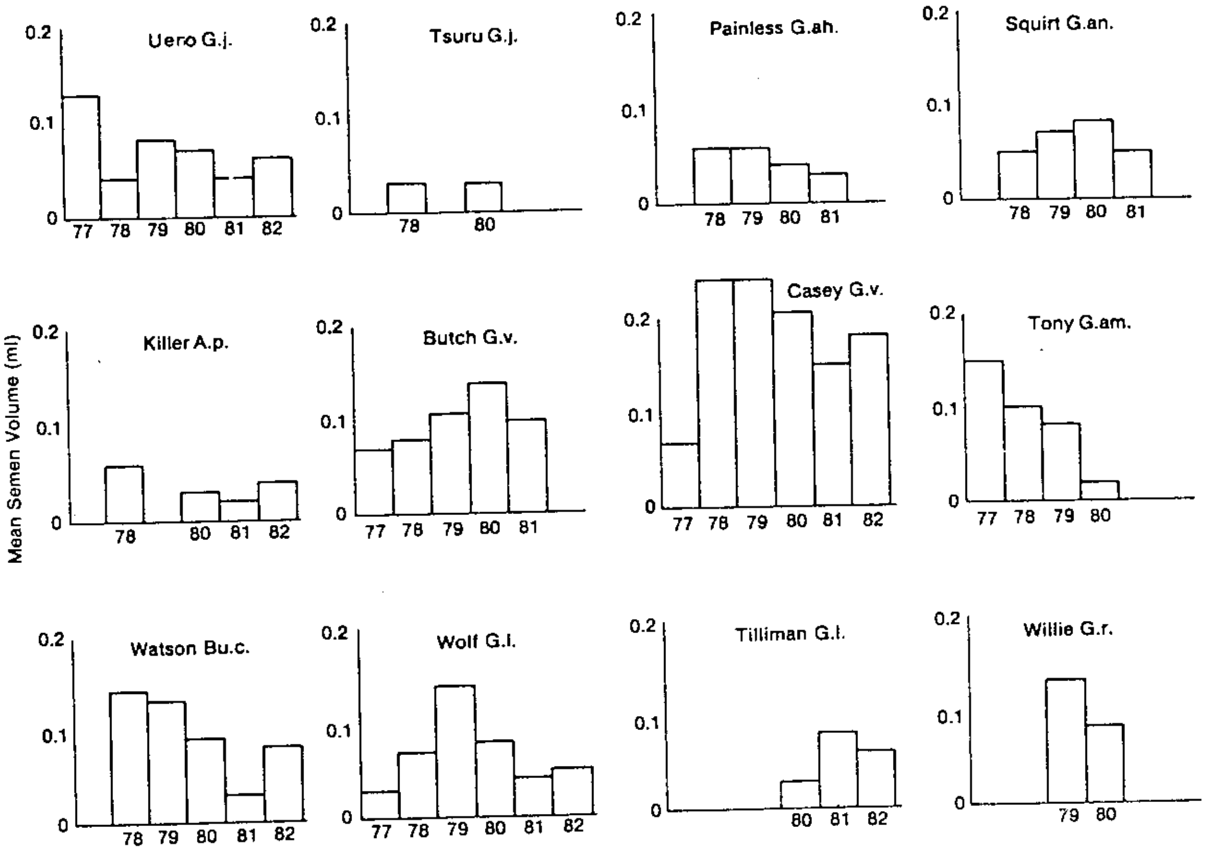

Fig. 1. Mean semen volumes collected from twelve cranes at ICF.

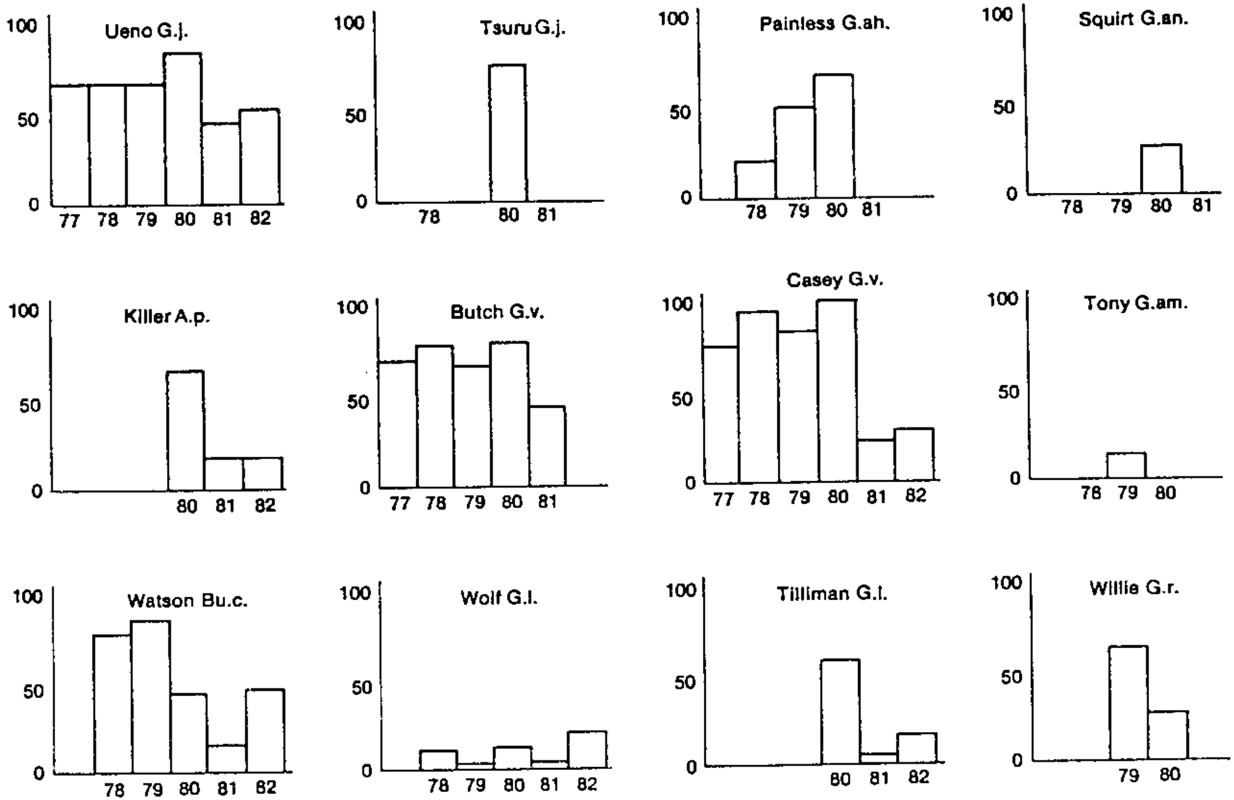

Fig. 2. The percentage of annual semen collections of 'A' quality for twelve birds at the International Crane Foundation

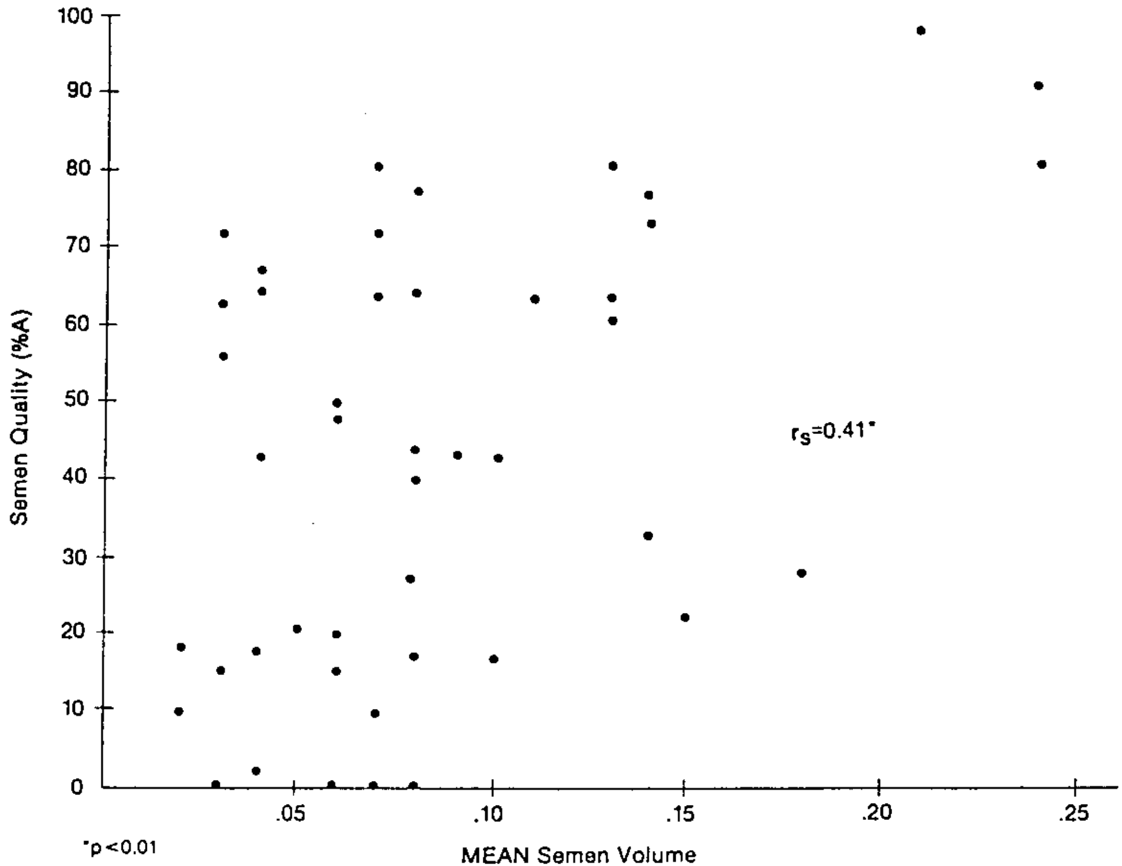

Fig. 3. The degree of association between mean semen volume and semen quality.

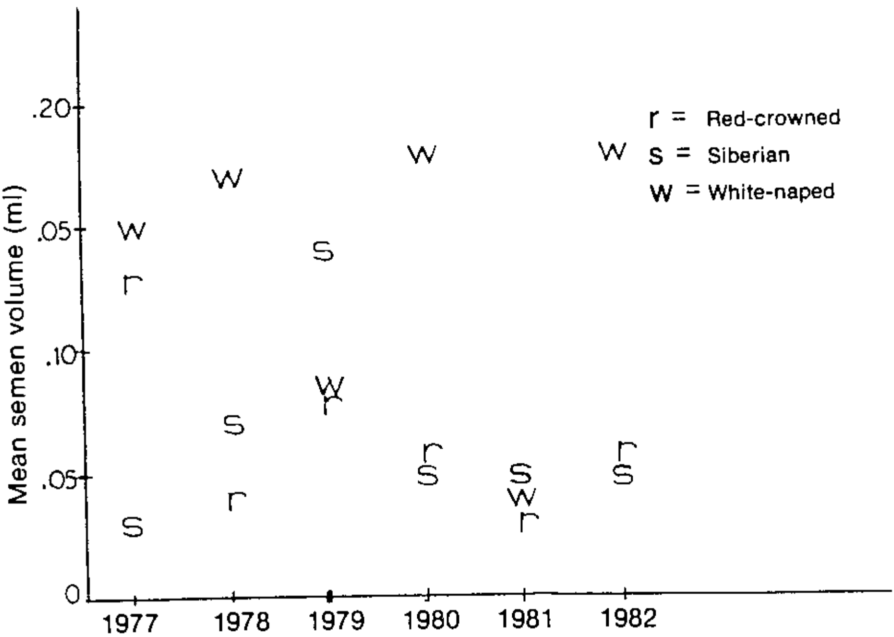

Fig. 4. The annual mean semen volume for three crane species at the ICF, 1977-1982.

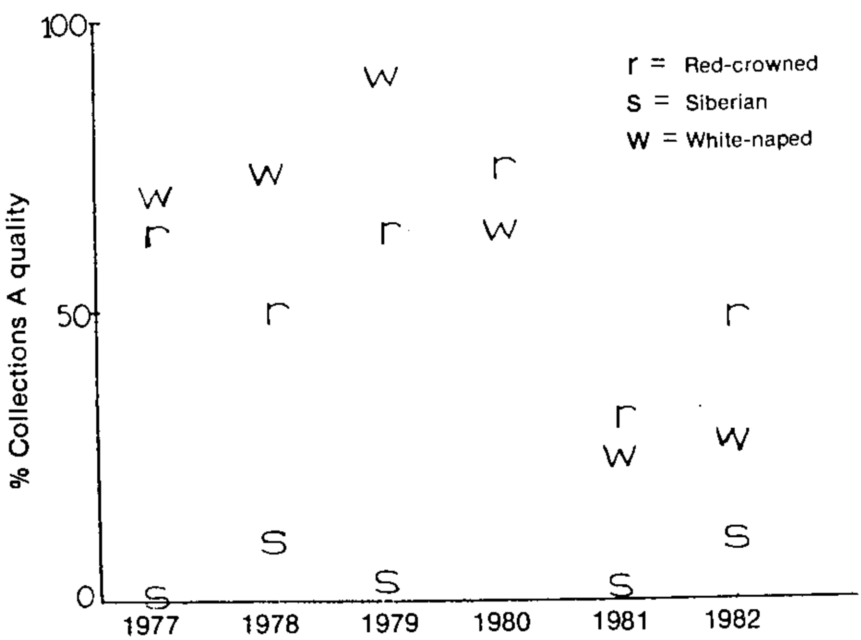

Fig. 5. Semen quality (percent of collections of A grade) for three crane species at the ICF, 1977-1982.

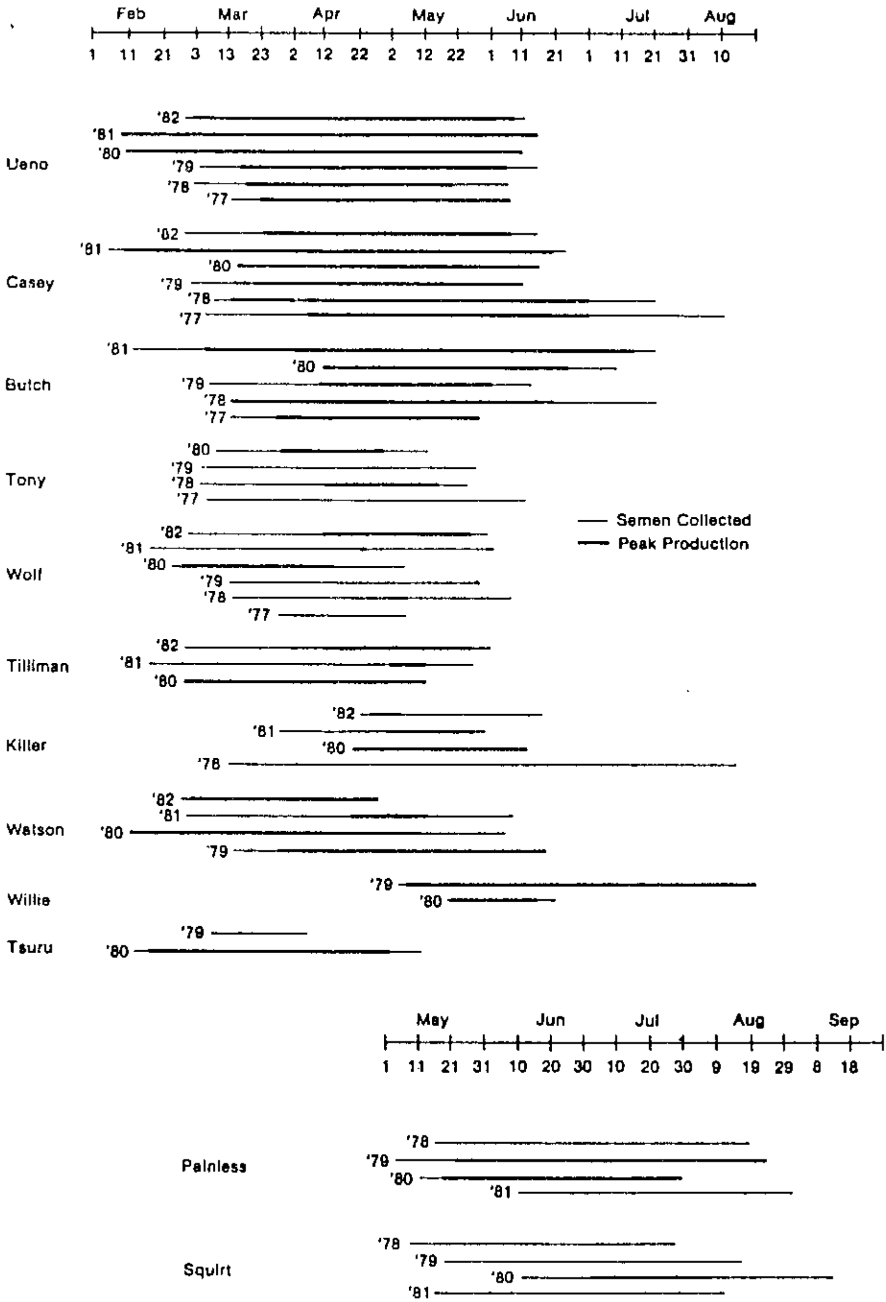

Fig. 6. Duration of peak semen production.

values are presented in *Fig. 6*. The period of production varied from 148 days (Butch, 1981) to 30 days (Tsuru). The peak production period varied from 139 days (Casey, 1981) to 1 day (Wolf, 1979 and 1981). The age of the male may be an additional variable, but this was not analyzed for this paper due to incomplete age data.

The mean number of successful semen collections and mean A days did not appear to increase or decrease with an increase in the number of years collected (*Table 2*).

DISCUSSION

The age of the male may be an additional variable. There is variation in the age when males first produce viahle semen. Red-crowned Cranes have produced semen with good concentration and motility at the age of three years. Indian Sarus Cranes (*G. a. antigone*) have produced good semen samples at four years. Siberian Cranes have produced semen at three years, but these samples contained no sperm. A Siberian has produced good semen at four years of age. A White-naped produced a sample at two years of age but good samples have not been collected from this species at ICF until four years of age. Sandhill Cranes (*G. canadensis pratensis*) at ICF have produced good semen at three years of age. Scott Derrickson (pers. comm.) reports that researchers at Patuxent Wildlife Research Center have obtained semen with some motile sperm from three year old Sandhill and Whooping cranes (*G. americana*). Samples with both good concentration and motility were obtained from four and five year old males.

The age of the male may be related to production, but age data is sometimes unavailable, particularly for wild-caught birds. On some birds for which we have accurate data, there does not appear to be any clear relationship between age and production. High qualtity samples were only sporadically obtained from males less than four and five years old, with one exception. High quality samples were consistently collected from a crane at least 35 years old (Casey, *G. vipio*), males between ten and 20 (Ueno, *G. japonensis*), and males between five and ten (Butch, *G. vipio*). A Siberian Crane at least 70 years of age is still producing viable semen.

There does not appear to be a relationship between age of male and time of production.

There does appear to be a relationship between dates and duration of semen production at ICF with when the species normally breeds in the wild. Ueno produces from early March to early or mid-June. This coincides with the Red-crowned breeding season in the wild. Samples from Casey and Butch were collected from early March until middle to late June. White-naped Cranes breed in the wild from mid-April to mid-May. Both these species breed in the wild in a temperate climate similar to that of Baraboo, Wisconsin. Semen has been collected from Siberian males from early April to late May, brought on early by the use of an extended artifical photoperiod. Siberian Cranes breed in the wild from late May to early June, a more restricted time period than other crane species, and the duration of semen production by captive birds at ICF is more restricted than other species. The Siberians may be programmed to produce for a very short period, since the breeding season is so short in their subarctic ecotope.

The Eastern Sarus and Brolgas breed from December through February in Australia. Captive males at ICF produce semen from May through August, later than the temperate species. Warm weather may be required to bring them into producing condition. A sprinkler system simulates the monsoon season for the Brolgas. Additionally, they must cope with the problem of warm season reversal.

The tropical species typically have a wider duration of production, followed by the temperate species and then the arctic species. At ICF, semen collections from a Wattled Crane extends from March into June. The breeding cycle of this species is unknown. It may be a fourteen month cycle. Archibald (pers. comm.) indicates that it is not random. West (1982) observed a pair that laid eggs in June four of five years.

I thank the avicultural staff at ICF (R. Besser, L. Hartman, S. Russman, and S. Swengel), D. Manry, and G. Archibald for their comments and support. This paper was based on one by C.A. Baumann (1981).

Appendix 1. Crane species names

Abbreviation	Scientific name	Common name
A.P.	*Anthropoides paradisea*	Stanley
Bu. c.	*Bugeranus carunculatus*	Wattled
G. am.	*Grus americana*	Whooping
G. an.	*Grus antigone*	Sarus
G.j.	*Grus japonensis*	Red-crowned
G.l.	*Grus leucogeranus*	Siberian
G.r.	*Grus rubicundus*	Brolga
G.v.	*Grus vipio*	White-naped

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THE EFFECTS OF ARTIFICIALLY COOLING CRANE EGGS AT THE INTERNATIONAL CRANE FOUNDATION

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ABSTRACT

Studies of wild crane incubation patterns have demonstrated that during the nest exchange process there is a cooling of the eggs. The International Crane Foundation has attempted to simulate this by subjecting the eggs to periods of cooling during the artificial incubation procedure. No differences were found in hatchability of cooled versus uncooled eggs; thus it was concluded that there is no benefit to artificially cooling eggs in a crane egg incubation program.

Captive propagation programs are becoming more and more important in the preservation of endangered species of birds. The International Crane Foundaiton (ICF) is dedicated to the study and preservation of the world's fifteen species of cranes, seven of which are endangered. Studies in the wild are used to help better captive crane management procedures. Examples include studying nutrition, habitat needs, mate selection, courtship, breeding behavior, incubation, and chick rearing. I will discuss some aspects of incubation behavior that have been studied in the wild and applied at ICF.

There have been several studies on wild crane incubation patterns. From these, we have discovered critical information needed to incubate the eggs of most captive crane species. Incubator temperature and relative humidity requirements have been studied and applied in our daily program (Putnam 1982). Now another critical interest is the cranes' nest exchange occurring in the wild and how it can be applied to our artificial incubation program.

R. Prange (unpl. report) observed a pair of incubating Eastern Greater Sandhill Cranes (*Grus canadensis tabida*) near Briggsville, Wisconsin. Both the male and female incubated the eggs. The male took one long session each day, replacing the female in early to mid-morning; the female replaced the male in the afternoon and incubated through the night. Prange described this pattern as being similar to the "pigeon pattern" as outlined by Skutch (1976). She found that the pair made frequent nest exchanges during the first 3 days of incubation, then switched to exchanging twice daily for the remainder of the period. During these exchanges the eggs were "cooled." However, the degree to which the eggs were cooled is unknown. She also determined that the incubation constancy averaged 96.1%. The constancy was influenced by ambient temperature. There was a negative correlation: as temperature increased, constancy decreased.

Table 1. Hatching Results at ICF 1979-1982.

Year	Conditions	% Hatch-ability	Sample	% Vitality	Sample
1979	Artificially incubated without cooling	50	22	NAa	NA
1980	Artificially incubated without cooling	45	20	30	20
1981	Naturally incubated more than 20 days	80	5	60	5
	Started under sandhills less than 7 days then artificially incubated with cooling	71	7	71	7
	Artificially incubated with cooling	77	31	55	31
1982	Naturally incubated more than 20 days	67	9	11	9
	Artificially incubated with cooling	65	17	24	17
	Artifically incubated without cooling	75	12	25	12
	Combined results	67	39	21	39
1983	Artificially incubated with cooling	33	3	33	3
	Artificially incubated without cooling	50	2	0	2

a=not available

Rol'nik (1955, 1970), a Soviet researcher, has suggested that cooling eggs periodically improved the hatchability of non-domestic bird eggs. He cooled eider duck eggs from the second day of incubation. The eggs were cooled 2-3 times daily for 5-30 minutes. They were also cooled when being turned, candled, and weighed.

Tret'yakov (1953) observed that domestic fowl abandoned the nest for any disturbance for between ten minutes and an hour on different days. Egg temperature dropped about 5°C after 30 minutes of cooling. During the first few days, the birds incubated irregularly. As a result the nest temperature dropped. Later, the nest temperature rose when the birds began sitting more closely.

Applying this field information, Tret'yakov (1937) tried using temperature fluctuations during artificial incubation of chicken and duck eggs. He found that, when periodic cooling was applied, the physiochemical indices of duck eggs due to incubation (refraction coefficient, electronegativity, etc.) were similar to those in natural incubation. By cooling goose eggs 2-4 times per day from the 15th day on he acquired a 14% higher hatchability. This cooling appeared to improve respiration. Ferdinandov (1931) considered that, in warming the egg, its contents expand, releasing carbon dioxide into the atmosphere. He found that the reverse occurred when the egg is cooling, i.e., as the egg is cooled, oxygen is sucked into the eggs from the atmosphere.

On the other hand, Landauer (1967) states that although these methods of cooling eggs have been used, he doesn't feel they are necessary for chicken eggs with the modern equipment used today. However, he did mention that Soviet investigators continue to claim advantages from cooling the eggs on a regular basis.

In order to simulate the nest exchanges in wild cranes, we have tried cooling the eggs in a refrigerator at 4°C for ten minutes 3 times daily for the first 3 days, (at 0800, 1200, and 1700 hrs) then twice daily (at 0800 and 1700 hrs) until just prior to hatching (Putnam 1982). We also weigh the eggs every two days and during the weighing the eggs cool for about 20 minutes at room temperature (Putnam 1982). In order to study the effectiveness of this cooling scheme, we cooled every other egg collected for each female (*Table 1*).

The data indicate that cooling does not improve hatchability; the difference is not significant when tested at the .05 level using the chi square test. The data were tested when years were pooled as well as in separate tests between particular years. Sample numbers were small, but this experiment was executed a sufficient number of times to preclude continuing sampling. Thus, the cooling process may lengthen the incubation period, but it has not proven to be essential for optimal incubation conditions.

ACKNOWLEDGEMENTS

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INFECTIOUS AND PARASITIC DISEASES OF CRANES: PRINCIPLES OF TREATMENT AND PREVENTION

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ABSTRACT

Little is known of the incidence and pathogenic effects of infectious and parasitic diseases in the world's 15 crane species. In addition to being a primary cause of crane mortality, diseases increase the susceptibility of an animal to predation, malnutrition, accidents, and other mortality factors and reduces its chances of survival during times of stress. Although the treatment and control of diseases of wild cranes is difficult, the management of captive cranes is becoming more and more successful through the use of intensive husbandry, preventive medicine, and parasite control programs. This paper describes some of the infectious and parasitic diseases of wild and captive cranes and outlines management principles for their control, especially in confinement.

INTRODUCTION

Little is known about the incidence and pathogenic effects of infectious and parasitic diseases in the world's 15 extant species of cranes. Because wild cranes are difficult to study, and, like other animals, generally secrete themselves or become vulnerable to predation when they become ill, much of the existing literature on crane diseases is based on studies of captives.

Infectious diseases in cranes appear to be mainly of bacterial origin. They are sporadic in occurrence, and occur primarily in birds that have been predisposed to infection by environmental or population stresses. Although various viral agents have been identified in cranes, their occurrence, distribution, and frequency are less well understood. Parasites are probably present in most wild and captive cranes, but usually in small numbers. Because parasites are opportunistic, the extent of their prevalence is frequently magnified in captivity and in areas where wild cranes congregate. Parasitism generally increases the susceptibility of an individual to other mortality factors, and reduces the bird's chances of survival during times of stress.

This paper reviews the major groups of infectious and parasitic diseases that are known to occur in the Gruidae, and discusses the general principles of detection and diagnosis, treatment, prevention, and monitoring.

INFECTIOUS DISEASES IN CRANES

Bacteria

At least 20 species or subspecies of bacteria, primarily *Enterobacteriaceae*, have been isolated from cranes (*Table 1*). The significance of most of these organisms in wild birds is not known, although some are potential pathogens of wildlife and man. *Pseudomonas* sp., *Streptococcus* sp., and beta hemolytic *E. coli* were considered primary causes of death in a number of Whooping Cranes (*Grus americana*) at the Patuxent Center that also suffered from pneumonia, airsacculitis, enteritis, and peritonitis.[13] *Escherichia coli*, *Pseudomonas* sp., *Proteus* sp., *Klebsiella* sp., *Bacillis* sp., *Staphylococcus* sp., *Micrococcus* sp., *Streptococcus* sp., and *Salmonella* type B contributed to the deaths of others.

Other *Salmonella* spp., including *S. balem*, *S. enteritidis*, *S. hartford*, *S. infantis*, and *S. java*, have been isolated from wild and captive Greater Sandhill Cranes (*Grus canadensis tabida*) in the U.S.[30 31 61 62] Salmonellosis in birds usually occurs as an intestinal infection which may result in enteritis and cause septicemia and death. Clinical signs of this disease are extremely variable. A related species of bacteria, *Arizona hinshawii*, was cultured from a Greater Sandhill Crane in the wild.[61 62] Both *Salmonella* and *Arizona* are known to cause high mortality in young poultry and waterfowl.

Infectious agents were responsible for the death of 25 Sandhill Cranes (*G. canadensis* spp.) at the Patuxent Center from 1966 to 1975.[14] The following general disease conditions were identified: pneumonia, omphalitis, septicemia, enteritis, and peritonitis. Bacteria considered primary etiological agents in the deaths of many of these cranes included *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Bacillus* sp. and *E. coli*.

Avian cholera is an infectious disease caused by the bacterium *Pasteurella multocida*. The disease has caused significant losses of wild birds (primarily waterfowl) in many parts of North America and is a potentially important disease of the Gruidae. One Sandhill Crane died during an outbreak of acute avian cholera in 1975[64] and 10 died during an avian cholera epornitic in 1970-71.[51] A possible cause of the latter outbreak was a late winter drought which resulted locally in a high concentration of birds and heavy fecal contamination of the water. Although avian cholera should be an important consideration in managing wild cranes, its impact and significance on crane populations require further study.

Avian tuberculosis is an infectious disease found most frequently in the North Temperate Zone where most species of cranes reside. The specific organism responsible for the disease is *Mycobacterium tuberculosis*; a strain that affects avian species is recognized. The pathogenic *Mycobacterium* sp. causes chronic conditions; lesions of an infectious granuloma type are commonly found in the liver and spleen. Fully developed lesions are characterized by caseous necrosis. The disease has been reported in many species of birds and was recognized in cranes in the late 1800 s in England. [32] Recently, pathogenic *Mycobacterium avium* was isolated from a wild Whooping Crane and a wild Sandhill Crane.[56] On postmortem examination, the liver of the Sandhill Crane had grossly visible tuberculosis-like (granulomas) lesions. Signs of infection in birds are variable and may be nonexistent, making diagnosis in living birds difficult.[32]

Other bacteria reported in cranes include *Clostridium* sp.,[33] *Edwardsiella tarda*,[58] *Erysipelothrix insidiosa*[19] and *E. rhusiopathiae*,[54] and a *Streptococcus* sp.(a) (which caused an arthritis, tendovaginitis, myocarditis, and endocarditis). The significance of these organisms in wild cranes remains unknown.

Viruses

Because serological examination and virus isolation are not routinely performed in most avian postmortem examinations, few viruses have been identified from cranes. Avian pox, a viral infection of birds characterized by discrete, proliferative lesions on the skin or mucous membranes of the mouth and upper respiratory tract, was reported in four (one

(a) *I. Huber and B. Maran, unpubl. data.*

Table 1. Bacteria isolated from cranes.

Bacteria	Host	Country	Wild or Captive
Arizona hinshawii	Sandhill Crane, Greater[61 62]	USA	wild
Bacillus sp.	Sandhill Crane[14]	USA	captive
	Whooping Crane[13]	USA	captive
Clostridium sp.	Demoiselle Crane[33]	Europe	captive
Edwardsiella tarda	Sandhill Crane, Florida[59]	USA	wild
Erysipelothrix insidiosa	Crowned Crane, E. African[19]	Africa	captive
E. rhusiopathiae	Crane[54]	-	-
Escherichia coli	Sandhill Crane[14]	USA	captive
Klebsiella sp.	Whooping Crane[13]	USA	captive
Micrococcus sp.	Whooping Crane[13]	USA	captive
Mycobacterium avium	Sandhill Crane[56]	USA	wild
M. tuberculosis	Crane[32]	-	-
	Whooping Crane	USA	wild (a)
Proteus vulgaris	Sandhill Crane[14]	USA	captive
Proteus sp.	Whooping Crane[13]	USA	captive
Pasteurella multocida	Sandhill Crane[51 64]	USA	wild
Pseudomonas aeruginosa	Sandhill Crane[14]	USA	captive
Pseudomonas sp.	Whooping Crane[13]	USA	captive
Salmonella belem	Sandhill Crane, Greater[31]	USA	captive
S. enteritidis	Sandhill Crane, Greater[61 62]	USA	wild
S. hartford	Sandhill Crane, Greater[30]	USA	-
S. infantis	Sandhill Crane, Greater[31]	USA	captive
S. java	Sandhill Crane, Greater[30]	USA	-
Salmonella sp.	Common Crane[49]	-	-
	Whooping Crane[13]	USA	captive
Staphylococcus sp.	Whooping Crane[13]	USA	captive
Streptococcus sp.	Sarus Crane	Yugoslavia	captive (b)
	Whooping Crane[13]	USA	captive

(a) R. Lange, pers. comm.
(b) I. Huber and B. Maran, unpubl. data.

free-living, three pen reared) Florida Sandhill Cranes (*G.c. pratensis*) in the U.S.[55] No detrimental effect on the general health of the cranes was observed. Pox infections in wild birds are usually self-limiting, unless there is a heavy infection of the eyelids or mouth.

Newcastle disease is a very contagious viral disease, primarily of avian species, that can vary from subclinical to fatal with degrees of systemic or localized nervous, respiratory, or gastrointestinal involvement. Newcastle disease virus (NDV) was isolated from captive Demoiselle Cranes (*Anthropoides virgo*) that died without prominent symptoms and had no typical lesions.[38] The disease was characterized as the velogenic viscerotropic type. Sandhill Cranes were exposed experimentally to NDV to determine susceptibility and host response.[58] Vaccinated cranes were well protected against velogenic challenge, whereas unvaccinated cranes shed the velogenic virus from the cloaca for weeks.

Another potentially important and pathogenic viral disease in cranes is inclusion body disease of crane virus (IBDCV). IBDCV caused the death of seven Sandhill Cranes, five Japanese Cranes (*Grus japonensis*), four Stanley Cranes (*Anthropoides paradisea*), and two Hooded Cranes (*Grus monacha*) at the International Crane Foundation (ICF), Baraboo, Wisconsin, in 1978.[22] Nondescript clinical signs including anorexia, lethargy, weakness, and breathing difficulties were observed for several days prior to death. Herpes was isolated from the livers and spleens of some of the Sandhill and Red-crowned Cranes. It is not known if IBDCV is endemic in wild crane populations or if it occurs only in captive flocks.[52] A similar herpes virus, however, was isolated from a West African Crowned Crane (*Balearica pavonina*) and a Demoiselle Crane in Austria in 1975[6] and from several other imported cranes in 1982 (G. Archibald, pers. comm.). Viruses of the herpes group can produce latent infections during which the virus apparently disappears from infected individuals for long periods of time. This characteristic can potentially aid in the spread of the virus, especially when translocating captive cranes to other facilities or to the wild.

PARASITIC DISEASES IN CRANES

Protozoa

More than 100 species of protozoa have been implicated in producing avian diseases. The coccidia *Eimeria gruis* and *E. reichenowi* are common parasites of Whooping Cranes and of five subspecies of Sandhill Cranes [Canadian (*G. c. rowani*), Florida, Greater, Lesser (*G. c. canadensis*), and Mississippi (*G. c. pulla*)] in North America (*Table 2*).[13 15 17 27 29 30] *E. gruis* and *E. reichenowi* have been reported in captive Demoiselle Cranes in India[46] and USSR.[63] *E. reichenowi* was also found in a captive Sarus Crane (*Grus antigone*) in India.[46] Unidentified coccidia have been reported in captive Japanese and White-naped (*Grus vipio*) Cranes in Japan[41] and in captive Sarus Cranes in the U.S.[26] *Isospora* spp., another coccidia, found in an East African Crowned Crane (*Balearica regulorum*) in India[3] and in the Whooping Crane in the U.S.[29] were considered spurious parasites. Coccidiosis was considered an important cause of mortality in captive White-naped, Japanese, Sandhill, and Whooping Cranes.[13 14 15 16 41 45] Coccidia probably infect all species of cranes and under certain conditions may cause illness and mortality.

Coccidiosis is the term applied to the diseased condition caused by infection with one or more of the many species of coccidia, a subdivision of the protozoan class Sporozoa. Coccidiosis infection is widespread among avian species. The parasites are host-specific; i.e., each species occurs in a single host species or in a limited group of closely related species. Infection may cause morbidity, diarrhea, and death. Parasitism by coccidia normally follows a 7 day cycle beginning when a bird ingests a fully mature, sporulated oocyst (sporozoan zygote) with food or water. The parasite develops through asexual and sexual stages in the intestinal tract and oocytes are passed from the bird with the droppings. Given sufficient moisture, oxygen, and suitable temperatures, oocysts survive in the environment (soil, litter, damp feed, etc.) where they can be ingested and infect other birds.

Although coccidiosis is generally recognized as a disease of the intestinal tract, *Eimeria* infections in Sandhill and Whooping Cranes may result in disseminated visceral coccidiosis (DVC).[45] In DVC, granulomatous nodules may form in many tissues and organs, or may result in bronchopneumonia, hepatitis, myocarditis, splenitis, and enteritis. At the Patuxent Center, this disease resulted in the death of a number of Sandhill and Whooping Cranes, especially those less than 2 weeks old. Although these protozoa occur in free-ranging Sandhill and Whooping Cranes, they undoubtedly represent a special problem for crane chicks (which are more susceptible to parasites and disease than older birds) raised in captivity.

Because concentrations of *Eimeria* sp. in the soil may increase substantially where cranes are held in close confinement, infections of extraintestinal coccidia may present a potential health problem for all captive cranes. Similar conditions may also exist in the wild wherever large numbers of cranes congregate. Crane chicks exposed to this parasite at an early age may succumb to disseminated visceral coccidiosis. Infections in adult cranes may be subclinical, but the disease probably increases the susceptibility of affected birds to other diseases, predation, starvation, and other mortality factors, thereby reducing their chances for survival during periods of stress.[45] Clearly, eimerian coccidiosis has to be considered in management practices involving cranes in captivity and in the wild.

At least two species of blood protozoans, *Haemoproteus antigonis* and *Leucocytozoon grusi*, are found in Florida[4 27 30] and Greater[28 30 61] Sandhill Cranes in North America; the

Table 2. Protozoa infections in cranes.

Protozoan	Host	Country	Wild or Captive
TELOSPORASIDA			
Eimeria gruis	Demoiselle Crane[46 63]	India, USSR	captive
	Sandhill Crane, Canadian[29]	USA	wild
	Sandhill Crane, Florida[17 27 29 30]	USA	wild, captive
	Sandhill Crane, Greater[17 30]	USA (a)	wild, captive
	Sandhill Crane, Lesser[17 29]	USA	wild, captive
	Sandhill Crane, Mississippi[29]	USA	captive
	Whooping Crane[13 15 29]	USA	wild, captive
E. reichenowi	Demoiselle Crane[46 63]	India, USSR	captive
	Sandhill Crane, Canadian[29]	USA	wild
	Sandhill Crane, Florida[17 27 29 30]	USA	wild, captive
	Sandhill Crane, Greater[17 29 30]	USA	wild, captive
	Sandhill Crane, Lesser[17 29]	USA	wild, captive
	Sandhill Crane, Mississippi[29]	USA	captive
	Sarus Crane[46]	India	captive
	Whooping Crane[13 15 29]	USA	wild, captive
Isospora sp.(b)	Crowned Crane, East African[3]	India	captive
	Whooping Crane[29]	USA	captive
Lankesterella sp.	Crowned Crane, E. African[48]	England	captive
Monocystis sp.(b)	Sandhill Crane, Greater[61]	USA	wild
coccida sp.	Japanese Crane[41]	Japan	captive
	Sarus Crane [26]	USA	captive
	White-naped Crane[41]	Japan	captive
Haemoproteus antigonis	Demoiselle Crane [20]	India	captive
	Sandhill Crane, Florida[27 30]	USA	-
	Sandhill Crane, Greater[30 61]	USA	wild
Haemoproteus sp.	Sandhill Crane, Greater[28]	USA	wild
Leucocytozoon grusi	Sandhill Crane, Florida[4 27 30]	USA	wild
	Sandhill Crane, Greater[28 30 61]	USA	wild
MASTIGASIDA			
Hexamita sp.	Demoiselle Crane[36]	-	-
PIROPLASMASIDA			
Nuttallia balearicae	Crowned Crane[47]	England	captive

(a) J.W. Carpenter, unpubl. data.
(b) Considered a spurious parasite.

former was also reported in a captive Demoiselle Crane in India.[20] Significance of these blood parasites in cranes is unknown, although they are known to cause mortality in other species of wild birds. *Haemoproteus* infects a wide range of hosts but is not considered a severe pathogen. Leucocytozoonosis is common in many wild and domestic birds throughout the world, with a marked pathogenicity in young ducks and turkeys. Both parasites require an insect vector as intermediate host.

Other protozoa reported in the Gruidae include *Lankesterella* sp. in an East African Crowned Crane,[28] *Hexamita* sp. in a Demoiselle Crane,[36] and *Nuttalia balearicae* in African crowned cranes.[47] Their significance, if any, to the health of wild and captive cranes remains unknown.

Helminths

A. Acanthocephala

Acanthocephalans (spiny-headed worms) appeared to be responsible for the deaths of two 18 to 20-day-old Whooping Cranes at the Patuxent Center.[13] Both birds died with peritonitis and ascites, with a concurrent pneumonia in one bird, resulting from intestinal perforation associated with acanthocephalan burrowing activities. An unidentified acanthocephalid was also found in a Lesser Sandhill Crane in the southwestern U.S.[5]

B. Cestoda

Unidentified tapeworms were found in a Florida Sandhill Crane[27 30] and in Lesser Sandhill Cranes in the U.S.[5]

C. Trematoda

At least nine species of flukes (*Brachylaima fuscatum*, *Echinostoma* sp., *Orchipedum jolliei*, *Prohyptiasmus grusi*, *Prosthogonimus* sp., *Stomylotrema vicarium*, *Strigea grus*, and *Tanaisia fedtschenkoi*) have been recovered from Sandhill Cranes in the U.S.[5 14 18 23 27 28 30 37 40 61] *O. jolliei* was recovered from the syrinx of a wild caught Greater Sandhill Crane that was shipped to the Patuxent Center from the western U.S.[14] The parasitic infection was considered secondary to pneumonia and shipping stress in the death of this bird. A Sarus Crane was host to *Echinoparyphium* sp.[50] and a Common Crane (*Grus grus*) was reported to be infected with *Orchipedum formosum*.[43] The overall impact of trematode infections in wild and captive cranes is unknown but is likely not significant.

D. Nematoda

At least 14 species of nematodes have been reported in cranes (*Table 3*). *Amidostomum* sp., *Capillaria* sp., *Chandlerella* sp., *Dispharynx nasuta*, *Prohyptiasmus grusi*, phylasolopterid sp., *Strongyloides* sp., *Syngamus trachea*, *Sciadiocara* sp., *Synhimantus* sp., *Trichostrongylus tenuis*, and *Tropisurus* sp. are known to infect Sandhill Cranes in the U.S.[5 27 28 30 61] *Cyathostoma coscorobae* and *Tetameres grusi* infect both Sandhill[10 14 28 30 37 61] and Whooping cranes;[13] the latter parasite is also known to occur in Common Cranes in the USSR.[53] In addition, an ascarid sp. was reported in the Common Crane[35] and *Tetrameres* sp., was recovered from a Sarus Crane.[50] Little is known about the pathogenic effects of these parasites in cranes, but some (i.e. *Tetrameres*, *Strongyloides*, *Syngamus*, *Trichostrongylus*, and *Dispharynx*) are known to be pathogenic in other birds and may cause illness in cranes under certain ecological conditions.[30]

Two nematodes, however, are known to be pathogenic to cranes. One species, *Capillaria* sp., contributed to the death or debility of several captive reared Mississippi Sandhill Cranes following their reintroduction to the wild. A second species, *C. coscorobae*, was responsible for the death of at least one Sandhill Crane at the Patuxent Center.[14] This bird died from pneumonia and asphyxiation following obstruction of the trachea with gapeworms. A low incidence of this parasite occurred in captive cranes at the Patuxent Center and were contributing factors in the deaths of several Sandhill and Whooping Cranes.[13 14]

Extoparasites

Four species of mites (Acarina), *Brephosceles petersoni*, *Geranolichus canadensis*, *Gruolichus wodashae*, and *Pseudogabucinia reticulata*, were identified on the feathers or skin of wild Sandhill Cranes[2] in the U.S. and a fifth species, *Haemaphysalis erinacei*, was recorded from a Common Crane in Yugoslavia.[57] Four species of biting lice (Mallophaga), *Esthiopterum brevicephalum*, *Gruimenopon canadense*, *Heleonomus assimilis*, and *Saemundssonia sagulata*, have been reported from Sandhill Cranes in the U.S.[24 27 28 30 39 61] With the exception of *S. sagulata*, these parasites also infest wild Whooping Cranes.[25 60] Two other species, *Pseudomenopon* sp. and *Menacanthus* sp., were recovered from Common Cranes.[42 44] Ectoparasites are probably of little pathological significance, although they could contribute to a crane's debilitating condition or potentially serve as vectors of disease.

Table 3. Acanthocephala and helminth infections in cranes.

Parasite	Host	Country	Wild or Captive
ACANTHOCEPHALA			
spiny-headed worm (sp.)	Sandhill Crane, Lesser[5]	USA	wild
	Whooping Crane[13]	USA	captive
CESTODA			
tapeworm (sp.)	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Lesser[5]	USA	wild
TREMATODA			
Brachylaima fuscatum	Sandhill Crane, Florida[27]	USA	wild
	Sandhill Crane, Greater[28]	USA	wild
Echinaparyphium sp.	Sarus Crane[50]	-	-
Echinostomidae	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
Echinostoma revolutum	Sandhill Crane, Greater[61]	USA	wild
Orchipedum formosum	Common Crane[43]	Czechoslavakia	-
O. jolliei	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[14 28 30 61]	USA	wild
	Sandhill Crane, Lesser[5]	USA	wild
Prohyptiasmus grusi	Sandhill Crane, Canadian[37]	USA, Canada	wild
	Sandhill Crane, Lesser[37 40]	USA, Canada	wild
Prosthogonimus macrorichis	Sandhill Crane, Greater[28 30]	USA	wild
Prosthogonimus sp.	Sandhill Crane, Greater[61]	USA	wild
Stomylotrema vicarium	Sandhill Crane, Florida[27 30]	USA	wild
Strigea gruis	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
	Sandhill Crane, Lesser[23]	USA	-
Tanaisia fedtschenkoi	Sandhill Crane, Florida[27 30]	USA	wild
NEMATODA			
Amidostomum sp.	Sandhill Crane, Greater[28 30]	USA	wild
ascarid sp.	Common Crane[35]	Hungary	-
Capillaria sp.	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30 61]	USA	wild
	Sandhill Crane, Mississippi	USA(a)	wild
Chandlerella sp.	Sandhill Crane, Greater[28 30]	USA	wild
Cyathostoma coscorobae	Sandhill Crane, Florida	USA(a)	captive
	Sandhill Crane, Greater[14]	USA	captive
	Whooping Crane[13]	USA	captive
Dispharynx nasuta	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
Phylasolopterid sp.	Sandhill Crane, Florida[27 30]	USA	wild
Sciadiocara sp.	Sandhill Crane, Lesser[5]	USA	wild
Strongyloides sp.	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
Syngamus trachea	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
Synhimantus sp.	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
Tetrameres grusi	Common Crane[53]	USSR	-
	Sandhill Crane, Canadian[37]	USA	wild
	Sandhill Crane, Florida[10]	USA	-
	Sandhill Crane, Greater[28 30 61]	USA	wild
	Sandhill Crane, Lesser[37]	USA	wild
	Whooping Crane	USA (b)	wild

Table 3. (cont.)

Parasite	Host	Country	Wild or Captive
Tetrameres sp.	Sarus Crane[50]	-	-
Trichostrongylus tenuis	Sandhill Crane, Greater[28 30]	USA	wild
Tropisurus sp.	Sandhill Crane, Lesser[5]	USA	wild

(a) J.W. Carpenter, unpubl. data.
(b) B. Tuggle, unpubl. data.

Table 4. Ectoparasites of cranes

Parasite	Host	Country	Wild or Captive
ACARINA			
Brephosceles petersoni	Sandhill Crane, Greater[2]	USA	wild
Geranolichus canadensis	Sandhill Crane, Greater[2]	USA	wild
Gruolichus wodashae	Sandhill Crane, Greater[2]	USA	wild
Haemaphysalis erinacei	Sandhill Crane[57]	Yugoslavia	-
Pseudogabucinia reticulata	Sandhill Crane, Greater[2]	USA	wild
MALLOPHAGA			
Esthiopterum brevicephalum	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30 61]	USA	wild
	Sandhill Crane, Lesser[24]	USA	-
	Whooping Crane[60]	USA	wild
Gruimenopon canadense	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30 61]	USA	wild
	Whooping Crane[60]	USA	wild
Heleonomus assimilis	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
	Whooping Crane[25]	USA	-
Menacanthus spp.	Common Crane[44]	Spain	-
Pseudomenopon sp.	Common Crane[42]	-	-
Saemundssonia sagulata	Sandhill Crane, Florida[27 30]	USA	wild
	Sandhill Crane, Greater[28 30]	USA	wild
Solenopsis invicta	Sandhill Crane[39]	USA	wild

PRINCIPLES OF DISEASE TREATMENT AND PREVENTION

Disease detection and diagnosis

Infectious and parasitic diseases can be detrimental to the health and productivity of cranes. However, by early detection and diagnosis of disease, treatment can be initiated to alleviate impact of the disorder and reduce recovery time. Captive cranes should be observed daily for indications of health problems as evidenced by reduced physical activity, decreased food consumption, or other clinical signs of disease.

Knowledge of normal crane behavior is important in recognizing signs of ill health, which are frequently detected through behavioral changes. Captive birds should first be viewed from a distance and for sufficient time for them to become accustomed to one's presence. Behavioral features which can be seen in this way include: (a) posture; alignment of body and tail; position of head, wings, feet, and toes; and characteristics of the eyes and beak; (b) respiratory rate and nature of breathing; (c) degree of steadiness in standing or walking; and (d) plumage characteristics.[1]

A closer examination of each bird generally involves disturbing the bird and ncouraging it to move to determine whether there is any unsteadiness of the legs, ımeness, incoordination, etc. Some behavioral manifestations frequently associated with isease have been previously reported and include (a) change in attitude; (b) altering of hysical characteristics; (c) changes in feeding behavior; (d) abnormal respiration (gaping, yspnea); (e) abnormal ambulation; and (f) central nervous system signs (depression, isorientation, change in temperament, nervousness, and abnormal posture of the head).[21]

In contrast to mammals, birds usually do not show clinical symptoms early in the course f a disease. Therefore, a complete physical examination (including palpation and uscultation) should be conducted if behavioral changes and/or abnormalities are etected. As an adjunct to the physical examination, a complete history of the bird should e obtained from personnel directly responsible for the care of the bird.

In addition, a number of laboratory tests may aid in diagnosing a disease condition. linical pathology, for example, is an important diagnostic tool for screening and haracterizing diseases in animals. Blood chemistry values of a crane compared with stablished baseline data[34] can be used to assess its physiological and pathological ondition. White blood cell count and differential, although difficult to perform, can rovide valuable clinical information in some cases and the hematocrit can be used to etermine if an individual bird is dehydrated, anemic, etc.

Whenever an infectious agent is suspected, cultures for bacteria should be taken and ntibiotic sensitivity should be conducted. Other diagnostic tools include fungal culturing, iral isolation, fecal and hematological examination for parasites, histopathology, adiography, and possibly eletrocardiography.

Iedical treatment

Most medical treatment principles developed for use in domestic animals are applicable cranes. Although specific medications (including drug selection, dosage, and route of dministration) and treatment regimes depend on diagnosis of the disease and evaluation f the patient's condition by a veterinarian, some general procedures can be followed.

When disease is recognized in a captive crane or a wild caught bird, the individual hould be isolated from other birds. Care must be taken when handling and treating ebilitated birds, and hospitalization is frequently necessary for treatment. This not only ermits intensive care, but also reduces the opportunity for disease transmission. 'ollowing isolation, supportive therapy may be instituted; this generally includes placing ie bird in an isolated, undisturbed area with adequate ventilation. Most sick birds require upplemental heat (about 29-30°C) which can be provided by a heater, heat lamps, or icubator (if patient is a chick). Frequent observation is required to monitor the patient's ondition and evaluate its response to treatment.

Supportive care also consists of providing high quality nutrition. If the bird is anorexic not consuming an adequate level of nutrients, it can be fed and medicated by gavage ube feeding) with a combination of hypoallergenic soybean food(a), a concentrated energy urce(b), instant rice cereal, vitamins, minerals and electrolytes. Because many sick anes suffer some degree of nutritional deficiency and usually eat less than normal when ospitalized, forced hyperalimentation can be essential for recovery.

In cases involving dehydration, emaciation, shock, stress, and electrolyte imbalance, ipportive care may also include fluid therapy (i.e., 5% dextrose, dextrose and Ringers olution, lactated Ringers, normal saline, and maintenance and replacement electrolyte olutions). Fluid type, volume, frequency, and route of administration (oral, intravenous, or ibcutaneous) vary with the patient's condition. In general, however, a bird needs 44ml/kg uid daily; this need increases in cases of dehydration and diarrhea. In situations where the ird is drinking, some medications and vitamin supplements such as Vitamin D_3 can be

) *Isomil (conc.), Ross Laboratories, Columbus, Ohio 43216*
) *Nutri-cal Evsco Pharmaceutical Corp., Buena, New Jersey 08310*

administered through the drinking water to reduce handling stress.

Antibiotic therapy is indicated in bacterial diseases and in certain instances in which there is opportunity for secondary bacterial infection. Since the pharmacokinetics (i.e., rate of appearance, plasma concentration, and biological half-life) of antibiotics in cranes are unknown, crane antibiotic studies were initiated by the National Zoological Park and the Patuxent Center. From the data obtained in these investigations, recommendations were made for the dosages and treatment intervals required to provide and maintain effective plasma concentrations for the following antibiotics: gentamicin, tylosin, cephalothin, cephalexin, and chloramphenicol.[7 8 18] Antibiotics can be administered orally (through the drinking water, gavage, or as a bolus) or parenterally (subcutaneous intravenous, or intramuscular).

Treating cranes for parasitism is indicated not only therapeutically when parasites are a cause of the pathologic condition, but also prophylactically because they are usually opportunists and may become pathogenic in times of concurrent disease, malnutrition, or stress. Although numerous parasiticides are available depending on the parasite, its site within the host, and the health status of the host, the following drugs are most frequently used at the Patuxent Center: coccidiostats — amprolium, Ethopabate, and triple sulfas; nematocides — thiabendazole or levamisole; cestodiacide — niclosamide; and pesticide (for ectoparasite control) — carbaryl. Treatment recommendations and other aspects of parasite control have been outlined previously.[12]

Disease and parasite prevention

To maintain healthy cranes in captivity, a number of disease prevention procedures are recommended. For example, stressful situations such as excessive handling or disturbance, poor ventilation, sudden temperature fluctuations, excessive moisture in indoor facilities, and overcrowding increase the susceptibility of a host to parasites and disease and, therefore, should be avoided.[12]

A rotating pen-use schedule can be implemented to reduce pathogen and parasite buildup in the soil of outdoor pens, particularly those in which young cranes are held.[12] Vacant pens are permitted to remain fallow for 1-2 years and, if possible, are limed and deep plowed. In addition, separate facilities are provided for newly hatched and young animals, since they are most susceptible to both infectious and parasitic diseases.[11]

Because cranes may be heavily parasitized and may be carriers of infectious agents when taken into captivity, new arrivals are separated for a minimum of 4 weeks from existing flocks so their health can be evaluated through physical and laboratory examinations.[12] New birds are examined for infectious and parasitic diseases, and are treated medically as needed.

Wild birds, especially other gruiformes, should be prevented from entering established crane facilities because they could introduce parasites and diseases.[12] In some facilities covered pens may be required to further isolate captive cranes from wild birds.

To maintain healthy captive cranes and to reduce parasitism, cranes should be examined routinely, administered anthelminthics, and treated prophylactically for ectoparasite infestations.[12] Parasite surveillance, therefore, is an extremely important procedure and when performed on a regular basis can control the parasitic diseases that are often responsible for high mortality in many captive situations.[9]

Husbandry

Proper husbandry procedures are important in maintaining the health of captive cranes. Cranes should be provided a nutritionally balanced diet *ad libitum*. Feeds for cranes at the Patuxent Center are specially formulated, and placed in suspended flow through feeders to ensure that they remain nutritious, palatable, clean, and free of contaminants.[11] Incorrect management practices such as exposing diets to sunlight or allowing feed to become damp or old can cause oxidation or other chemical destruction of essential nutrients.[12] Spilled food, which might become wet and moldy and a medium for food or air borne infections is picked up routinely.[11]

Fresh, constantly flowing water should be available for cranes at all times. Use of elevated drinking cups at the Patuxent Center appears to be the most sanitary watering system available and requires a minimum of maintenance, even in winter.[11] The watering devices are examined daily and cleaned periodically.

Routine sanitary procedures are also essential for the control of disease in captive cranes.[11] Environ(c) has proven to be an excellent bactericidal and virucidal agent for the routine disinfection of facilities, equipment, feeding utensils, and water pans. In addition to good hygiene, the areas are generally restricted only to people involved in handling, feeding, caring for, or observing cranes — a policy which also helps prevent the spread of infectious and parasitic diseases.[12]

Pens are kept free of debris and trash and are mowed regularly in an attempt to make conditions less suitable for intermediate and paratenic hosts. Rodent control is also practiced because rodents can spread disease and parasites between areas.

Disease Monitoring

It is recommended that a physical examination, including palpation and auscultation, be given each crane at least annually. Depending on geographical location and previous history of disease, blood smears may need to be prepared during the examination, stained with Wright's Giemsa or Wright's stain, and examined for hemoprotozoa. In addition, fecal samples should be obtained, placed in a supersaturated solution of sodium nitrate, centrifuged at 1500rpm for 5 minutes, and examined under a 10x objective for intestinal parasites.

As an integral part of this examination, blood is obtained via venipuncture, placed in a plain sterile tube, permitted to clot, and centrifuged. The serum is then examined for antibodies to diseases such as *Salmonella typhimurium* (paratyphoid), *S. typhoid*, Newcastle disease virus, etc., which may be indigenous to the area.[11]

Specific monitoring procedures may need to be developed for a collection of cranes with actual or potential disease problems. For example, surveillance of cranes at ICF for IBDCV includes monitoring serum neutralizing antibody, collecting swab samples to test for virus shedding, and using sentinel cranes in the quarantine areas.[52]

SUMMARY AND CONCLUSIONS

A number of infectious and parasitic diseases have been reported in free ranging and captive cranes. The more important of these are salmonellosis, avian cholera, tuberculosis, avian pox, inclusion body disease of cranes, Newcastle disease, coccidiosis (and disseminated visceral coccidiosis), and leucocytozoonosis. Some diseases such as disseminated visceral coccidiosis and inclusion body disease have been important mortality factors in captive cranes and are potential mortality factors in wild cranes. Many disease agents, however, are probably present in relatively low frequency in crane populations, and become pathogenic only periodically, particularly in times of increased population density and other stressful situations. It appears that migratory cranes have a more varied parasite fauna and a greater opportunity for exposure to a wider range of infectious disease agents than their confined or nonmigratory counterparts.

Little is known about the diseases of cranes in the wild, and little guidance can be offered to control outbreaks of diseases in wild birds. Nevertheless, disease should be given consideration in management activities which involve population manipulation in the wild such as the reestablishment or establishment of crane populations and the use of supplemental feeding procedures that attract and concentrate cranes. As available crane habitat becomes reduced worldwide and the concentration of cranes in staging, breeding, and wintering areas increases, the potential adverse impact of disease on crane survival will increase. Well-established principles of animal health, management, and husbandry can be used in such instances, however, as tools to minimize the risk of disease outbreaks.

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Endangered species of cranes are being intensively propagated in an attempt tı minimize the threat of their becoming extinct. As a consequence of this intensive propagation, avian diseases that were not previously known to affect cranes have beer diagnosed and treated, and newly recognized diseases have been described. Highly specialized animal management practices have been instituted with these endangered species to ensure and promote successful breeding and rearing. Paramount among these are disease control measures that include the provision of nutritionally balanced diets, the use of established and newly created husbandry practices, the administration of therapeutic and prophylactic parasiticides, and the maintenance of a living environment as free from unnecessary stress as possible. In addition, measures such as pen rotation, quarantining new arrivals, and segregating cranes on the basis of age classes, contribute to healthful environments. Much of the information that is known about the diseases of cranes has come about from captive propagation; however, voids in the present knowledge of crane diseases need to be explored. Continued captive propagation and an expanding knowledge of the diseases of cranes promise to contribute to improved management for both captive cranes as well as their free ranging, wild counterparts.

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SUMMARY OF MORTALITY OF 14 SPECIES OF CRANES AT THE INTERNATIONAL CRANE FOUNDATION, 1972-1982

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ABSTRACT

Mortality for 14 of the world's 15 species of cranes at the International Crane Foundation, 1972-1982, is summarized. The 118 deaths included 78 (66%) adults, 16 (14%) immatures, and 23 (20%) downy young. The age of one bird was unknown. 41 (35%) of the cranes were males, 44 (37%) were females, and 33 (28%) were of unknown sex. Traumatic conditions were responsible for 33 (28%) of the deaths. These included aggression, injury or accident, and predation. Thirty one (26%) of the deaths were from infectious diseases such as inclusion body disease of cranes virus (IBDCV), aspergillosis, bacterial enteritis, erysipelothrix, and salmonellosis. Other disease conditions, nutritional complications, anatomical abnormalities, neoplasia, and miscellaneous conditions were other causes of death. Examined here are the circumstances of mortality with a review of aviculture procedures to help diminish the losses of captive cranes at the International Crane Foundation.

A wide variety of mortality has occurred among the captive cranes at the International Crane Foundation (ICF) since its inception in 1972 as a center for world-wide efforts in crane preservation. In 10 years (1972-1982), 14 of the world's 15 crane species have occupied the Baraboo, Wisconsin facility and all of these have been induced to breed. The Black-necked Crane (*Grus nigricollis*) is the only species ICF lacks. As a result of 10 years experience with cranes, ICF has refined its management techniques and developed a conscientious aviculture program designed to maximize reproduction and minimize losses of captive cranes. A review of past mortality reveals strengths and weaknesses in the program that may otherwise go unnoticed, and from this, more improvements may be made. I have summarized the cases of mortality from 1972-1982 with an overall look at improvements incorporated into our aviculture program that are essential for the successful management of cranes in captivity.

METHODS

The National Wildlife Health Laboratory (NWHL) in Madison, Wisconsin, has performed the necropsies on most of ICF's dead cranes since 1975 (L.N. Locke, pers. comm.). After a crane dies, the carcass is sent to the NWHL for a post-mortem examination. The NWHL sends us a preliminary report and a final diagnosis on the cause of death of the crane. For this review I have used the diagnostic reports to present a qualitative summary of ICF's total mortality.

Birds were aged by their plumage: Downy young (0-2 months), immatures (2-12 months), and adults (greater than 12 months). This method of determining age was used by the Patuxent Wildlife Research Center (PWRC) for reviews of Sandhill and Whooping Crane mortality (Carpenter et al. 1976, Carpenter and Derrickson, 1982). The sex of some birds is unknown because of damage done to carcasses, a lack of gonadal differentiation in young birds, or the absence of this information on individual records or necropsy reports.

RESULTS

A total of 118 cranes of 14 species have died at ICF in the past 10 years. Total mortality consisted of 4 (3%) West African Crowned Cranes (*Balearica pavonina*), 10 (9%) East African Crowned Cranes (*B. regulorum*), 1 (1%) crowned crane hybrid (*B. regulorum* x *B. pavonina*), 7 (6%) Demoiselle Cranes (*Anthropoides virgo*), 6 (5%) Stanley Cranes (*A. paradisea*), 1 (1%) Wattled Crane (*Bugeranus carunculatus*), 4 (3%) Siberian Cranes (*B. leucogeranus*), 18 (16%) Sandhill Cranes (*Grus canadensis*), 13 (11%) Sarus Cranes (*G. antigone*), 2 (2%) Brolgas (*G. rubicunda*), 7 (6%) White-naped Cranes (*G. vipio*), 7 (6%) Common Cranes (*G. grus*), 8 (7%) Hooded Cranes (*G. monacha*), 4 (3%) Whooping Cranes (*G. americana*), and 26 (22%) Red-crowned Cranes (*G. japonensis*).

Seventy-eight (66%) of the cranes were adults, 16 (14%) were immatures, and 23 (20%) were downy young. Forty-one (35%) were males, 44 (37%) were females, and the sex of 33 (28%) birds was unknown.

Crane losses have been attributed to traumatic conditions, infectious disease, other disease conditions, nutritional complications, anatomical abnormalities, neoplasia, and miscellaneous conditions. Sixteen (14%) of the deaths had undetermined causes.

Because of the adaptation of different crane species to different climates, the crane family can be divided into two groups. The northern latitude species are the Siberian, Common, Demoiselle, White-naped, Sandhill, Hooded, Whooping, and Red-crowned Cranes. These species appear to be more cold-hardy than the southern species and more capable of withstanding Wisconsin's winters. Young of these species have been hatched at ICF in May, June, and July. The greatest concentration of mortality is, therefore, during these three months, because the downy young are particularly sensitive to infection and the stresses associated with hatching and hand rearing (Carpenter et al. 1976). *Fig. 2A* depicts monthly incidence of mortality for the northern species.

The southern species are the Sarus, Brolga, Stanley, Wattled, East African Crowned, and West African Crowned Cranes. *Fig. 2B* illustrates the monthly incidence of mortality for these cranes. Their breeding season differs from that of the northern species, as evidenced by the September, October, and November losses of downy young.

Causes of mortality for all individuals, the age at death, and the number and percent of losses are listed in *Table 1*. This table is the same format as Carpenter's table for Sandhill Crane mortality at PWRC (1976). *Table 2* lists the number of losses and causes of mortality for each species.

CAUSES OF MORTALITY

Traumatic conditions

Traumatic conditions resulted in the deaths of 33 (28%) cranes. Ten of these suffered from aggression and were killed by another crane or cranes. The unsupervised introduction of a crane into a small flock, or the pairing of incompatible birds may permit such lethal aggression. Our most recent loss due to aggression was an adult male Common Crane introduced into a well established group of 7 nonbreeding adult male cranes. The group was watched for several days with no apparent disorder; however, on the afternoon of the third day, the introduced bird was found dead with multiple injuries to the head and neck.

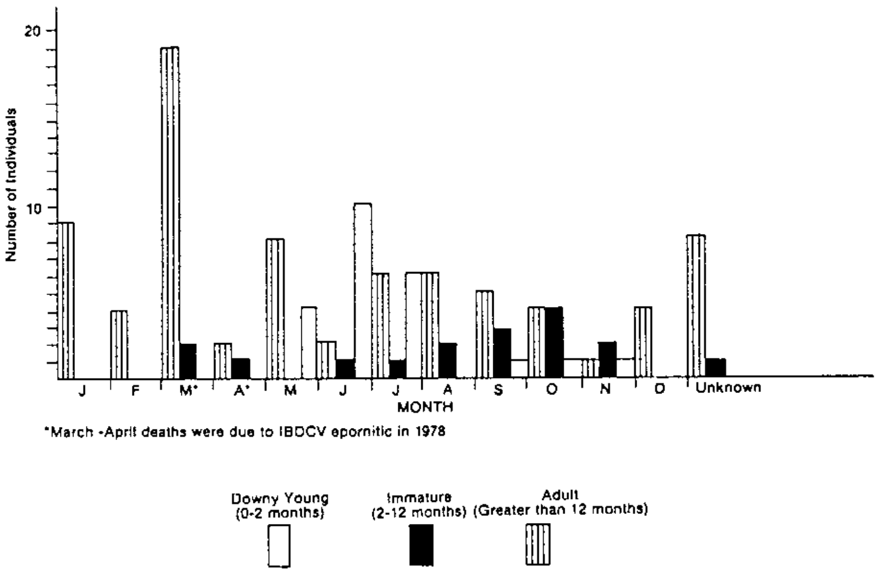

Fig. 1. Monthly incidence of mortality for all cranes at the International Crane Foundation, (1972-1982).

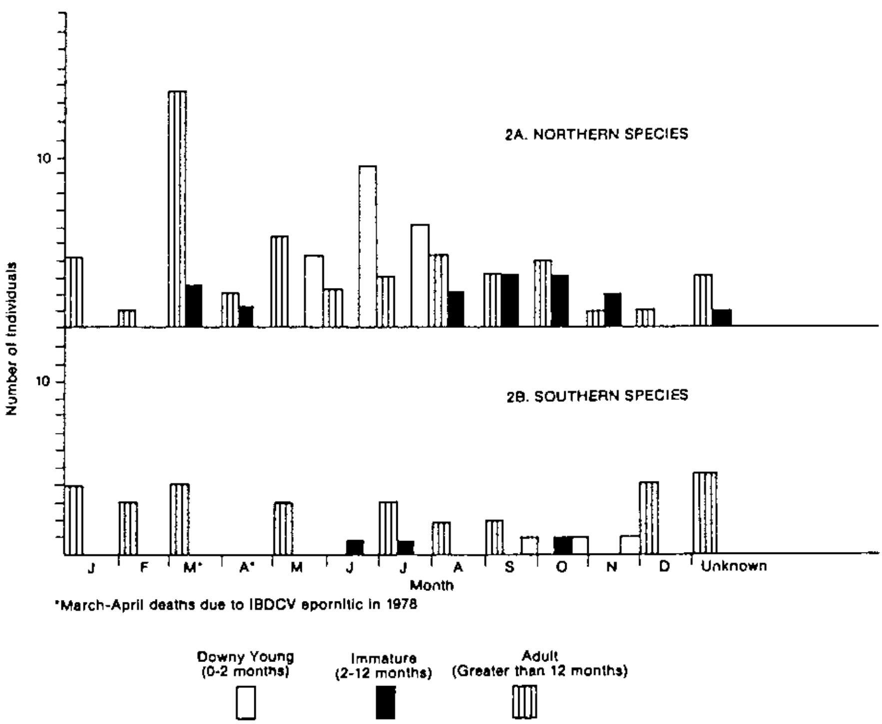

Fig. 2. Monthly incidence of mortality for (*2A*) northern species and (*2B*) southern species of cranes at ICF, (1972-1982).

Table 1. Causes of mortality for 14 species of cranes at the International Crane Foundation, 1972-1982.

Major group of mortality No. & (%)	Primary mortality factor	Contributing mortality factors	Number of individuals affected per age class (%)			Total individuals affected
			Downy young	Immature	Adult	
Traumatic conditions 33 (28)	Aggression 10 (9)		2 (2)	1 (1)	7 (6)	10 (9)
	Injury or accident 14 (12)	Fractures	1 (1)	3* (3)	7 (6)	11 (10)
		Blood loss			1 (1)	1 (1)
		Capture myopathy			1 (1)	1 (1)
		Ruptured gizzard due to force-feeding	1 (1)			1 (1)
		Predation				
		(raccoon)		2 (2)	5 (4)	7 (6)
		(owl)		1 (1)	1 (1)	2 (2)
		9 (8)				
Infectious disease 31 (26)	IBDCV 22 (19)			2 (2)	20(17)	22 (19)
	Inclusion body hepatitis 1 (1)				1 (1)	1 (1)
	Aspergillosis 4 (3)		3 (3)		1 (1)	4 (3)
	Salmonellosis 1 (1)		1 (1)			1 (1)
	Erysipelothrix 2 (2)				2 (2)	2 (2)

Table 1 (cont.)

Major group of mortality No. & (%)	Primary mortality factor	Contributing mortality factors	Number of individuals affected per age class (%) Downy young	Immature	Adult	Total individuals affected
Infectious disease (con't)	Bacterial enteritis 1 (1)		1 (1)			1 (1)
Other disease conditions 17 (14)	Hepatitis 5 (4)	Bronchitis			1 (1)	1 (1)
		Peritonitis			1 (1)	1 (1)
		Myocarditis			1 (1)	1 (1)
		Cardiac hemorrhage			1 (1)	1 (1)
		Valvular endocarditis, nutritional myopathy			1 (1)	1 (1)
	Bumblefoot 2 (2)	Tendosinuvisitis, endocarditis			1 (1)	1 (1)
		Valvular endocarditis, armyloidosis			1 (1)	1 (1)
	Septicemia 2 (2)				2 (2)	2 (2)
	Pneumonia 5 (4)		2 (2)	1* (1)	2 (2)	5 (4)
	Enteritis 1 (1)	Septicemia, nutritional cardiomyopathy			1 (1)	1 (1)

Table 1 (con't.)

Major group of mortality No. & (%)	Primary mortality factor	Contributing mortality factors	Number of individuals affected per age class (%) Downy young	Immature	Adult	Total individuals affected
Other disease conditions (con't.)	Pericarditis 1 (1)	Hepatitis, gastroenteritis			1 (1)	1 (1)
	Omphalitis 1 (1)		1 (1)			1 (1)
Nutritional conditions 3 (3)	Nutritional myopathy 1 (1)				1* (1)	1 (1)
	Impacted gizzard 2 (2)	Aspergillosis	1 (1)			1 (1)
			1 (1)			1 (1)
Anatomical abnormalities 3 (3)	Leg deformity 3 (3)		1 (1)	2* (2)		3 (3)
Neoplasia 2 (2)	Carcinoma 2 (2)				2 (2)	2 (2)
Miscellaneous conditions 13 (11)	Cold-related 4 (3)				1* (3)	4 (3)
	Anaesthesia 4 (3)	Fracture		2 (2)		2 (2)
		Laparoscopy		1 (1)		1 (1)
		Surgery to remove broken wing			1 (1)	1 (1)
	Old age 1 (1)				1 (1)	1 (1)
	Atherosclerosis 1 (1)	Bumblefoot			1 (1)	1 (1)

Table 1 (cont.)

Major group of mortality No. & (%)	Primary mortality factor	Contributing mortality factors	Number of individuals affected per age class (%)			Total individuals affected
			Downy young	Immature	Adult	
Miscellaneous Conditions (cont.)	Disseminated intervascular coagulation 1 (1)				1 (1)	1 (1)
	Intussusception of the gut 1 (1)		1 (1)			1 (1)
	Blind 1 (1)	Failure to thrive	1 (1)			1 (1)
Undetermined 16 (14)			5 (3)	1 (1)	10 (9)	16 (14)
Total			23 (20)	16 (14)	78 (66)	118 (100)

* an asterisk indicates one bird was euthanized.

Table 2. Number of losses and causes of mortality for each species of crane at the International Crane Foundation, 1972-1982.

	Incision of gizzard	Erysipelothrix	Bacterial enteritis	Salmonellosis	Nutritional myopathy	Impacted gizzard	Leg deformity	Carcinoma	Hepatitis	Omphalitis	Pneumonia	Pericarditis	Bumblefoot	Enteritis	Septicemia	IBDCV
East African Crowned		1							1			1	1	1		
West African Crowned		1									1					
East-West African Crowned										1						
Demoiselle					1											
Stanley																4
Wattled									1							
Siberian			1			1										
Sandhill							1									9
Sarus							1	1	1						2	
Brolga									1							
White-naped												1				
Common												1				
Hooded								1								2
Whooping																
Red-crowned	1		1	1		1	1	1				2		1		6

Table 2. (cont.)

	Inclusion body hepatitis	Aspergillosis	Disseminated intervascular coagulation	Intussusception of the gut	Blind	Old Age	Atherosclerosis	Cold-related	Hemorrhage	Predation	Fracture	Anaesthesia	Aggression	Capture myopathy	Undetermined	Total
East African Crowned						1	1				1				2	10
West African Crowned								2								4
East-West African Crowned																1
Demoiselle										3			1		2	7
Stanley										1		1				6
Wattled																1
Siberian													1			4
Sandhill	1								1		2		2		2	18
Sarus								2		1	2				3	13
Brolga											1					2
White-naped										1	2				3	7
Common		1									2		3			7
Hooded										2			1		2	8
Whooping			1							1	1			1		4
Red-crowned		3		1	1						1	2	1		2	26

The second Hooded Crane chick to hatch from a two egg clutch incubated by the parents may have been killed by its sibling. It had pipped the egg but on the following morning the parents were found trying to feed it to the first chick. In the wild, cranes usually lay 2 eggs, and while both may hatch, usually only one chick survives. There is the possibility that one chick kills the other in competition for food, but further study must be done on this.

Accidental entry by one crane into the pen of another often ends in the death of the interloper. During the breeding season, intruders are particularly vulnerable to attack due to the increased territory defense by the crane pair whose pen has been entered. One disconcerting incident was that of a male Red-crowned Crane infected with a then-undetected cancer, who killed his mate as they were constructing their nest. Possibly, the male's disease disrupted his behavior and led to the death.

Fourteen cranes died as a result of injury or accident. Eleven of these were fractured bone injuries. One of the most outstanding incidents was an adult male Whooping Crane that broke its bill on the chain link fence when an assemblage of hot air balloons flew over the crane pens. He had to be force-fed in the ensuing weeks of recovery, but broke a femur during one force-feeding attempt. The fractured bones were pinned, the leg set in a cast, and the bird arranged in a sling, but to no avail. The 10 other deaths were from injuries sustained on impact with fences or structures, or were unknown accidents. Blood loss precipitated the death of a Sandhill Crane that cut her jugular vein with a claw during restraint. The lacerated incision on the gizzard of a downy young Red-crowned Crane was due to force-feeding.

Both avian and mammalian predators kill cranes. Two Demoiselle and 2 Hooded Cranes were kept in nonflight netted pens and were believed to have been killed by Great Horned Owls (*Bubo virginianus*), or raccoons (*Procyon lotor*). The pen that was accessible to raccoons was no longer used after that. Evidence of raccoons around the crane pens has occurred in recent years, but until 1982 did not appear to be a problem. In that year, however, over a period of three weeks, raccoons killed 5 cranes, 4 of which were housed in flight netted pens.

Infectious diseases

Thirty-one (26%) of the deaths at ICF were caused by infectious diseases. The most outstanding single incidence of mortality was the outbreak of the IBDCV which killed 21 cranes. Twenty of these birds died in March and April, 1978, showing signs of lethargy, anorexia, and diarrhea 1-2 days before death. One adult Red-crowned Crane's death in late August of that year was attributed to late effects of IBDCV, and an adult male Greater Sandhill Crane (*G. c. tabida*) appeared active and healthy up until the day in November, 1980, that it suffered from a heart attack and died. Its liver had inclusion bodies consistent with those caused by IBDCV.

Aspergillosis was the second leading cause of death by infectious disease, and killed four cranes. Three of these were downy young Red-crowned Cranes: 1 was being treated simutaneously for aspergillosis and gapeworm, 1 was treated for a general respiratory infection, and 1 may have been weakened by a retained yolk sac. The fourth bird, an adult Common Crane was treated first for gapeworm and then for general respiratory infection. Erysipelothrix, bacterial enteritis, and salmonellosis were other diseases fatal to cranes.

Other disease conditions

In several instances, disease was suspected but no apparent causative organism was defined. Causes of mortality in 17 (14%) cranes were diagnosed a pneumonia, hepatitis, bumblefoot, enteritis, pericarditis, septicemia, or omphalitis. One Hooded Crane that died had bouts of feather picking that flared up periodically over the course of 2.5 years before its death. Bronchitis and chronic systemic infection were reported in conjunction with the final diagnosis of hepatitis.

Nutritional conditions

Three (3%) cranes died from nutritional complications. One adult Demoiselle Crane was euthanized and discovered to have nutritional myopathy. Impacted gizzards were responsible for the deaths of two downy young: One, a 5 day old Red-crowned Crane, and the other, an 8 day old Siberian Crane that also had aspergillosis.

Anatomical abnormalities

The 3 (3%) deaths due to anatomical abnormalities all resulted from leg deformities. The two immature victims were a Florida Sandhill Crane (*G. c. pratensis*) and a Red-crowned Crane. The downy young bird was a newly hatched Eastern Sarus Crane (*G. a. sharpii*). We noticed an abnormal leg rotation immediately after the chick hatched, and tried to correct it by taping him in the normal position to a flat surface. The bird succumbed to this stress after 48 hours.

Neoplasia

Two (2%) cranes died from carcinoma.

Miscellaneous conditions

Miscellaneous conditions accounted for 13 (11%) deaths. These included fatalities from atherosclerosis, old age, blindness, disseminated intervascular coagulation, intussusception of the gut, cold, and anaesthesia.

Four deaths that occurred during the winter months appeared related to the cold or were hastened by cold-related injuries. Two Sarus Cranes appeared healthy up until they were found dead on relatively cold days. One West African Crowned Crane failed to survive a toe injury that resulted in extensive hemorrhaging. During January 1981, the other West African Crowned Crane froze one foot, which was later removed and replaced with a prothesis. The prothesis came off and could not be replaced. The following winter, this crane was euthanized when its healthy foot froze.

Anaesthetic deaths are those deaths that occurred during, or shortly after, surgery. It is not immediately evident what the primary mortality factor was in any of the four cases. A male adult Red-crowned Crane died following surgery to remove an old broken wing that had thwarted his copulation attempts. An immature isolation-reared Stanley Crane, anaesthetized for laparoscopy, died at the onset of surgery. Fear of people may have triggered a physiologic response in this crane that resulted in her sudden death. An immature Siberian Crane died 48 hours after 2 bouts of surgery to pin a broken femur. Initially this bird suffered from an injured hock. Radiographs revealed a lack of bone ossification at the hock joint, so the diet was supplemented with calcium, phosphorous, and vitamin D. Further x-rays showed improvement in the bone structure. However, the bird fell and broke its good leg while trying to adapt to a leg wrap put on the injured hock. The repair of a seemingly correctable disorder then facilitated another injury that was fatal.

Undetermined

Sixteen (14%) deaths were from undetermined causes. Five were downy young from 0-1.5 months old. Of the adult birds, 1 Eastern Sarus Crane was harassed persistently by Red-winged Blackbirds (*Agelaius phoeniceus*) nesting in its enclosure. The necropsy revealed an enteritis which may have weakened the crane.

DISCUSSION

The refinement of crane management techniques developed over many years is essential in the success of ICF's aviculture program. A new exhibit building, the Johnson Exhibit Building, has been built at ICF and designed in such a way that crane mortality should be reduced. The features of this building will be emphasized in this discussion to illustrate how structural design may prevent crane losses.

Just as cranes in the wild are not immune to mortality, neither are they in captivity. Many deaths are preventable, particularly those that result from poorly maintained facilities, departure from critical husbandry practices, or inattentiveness of caretakers. Daily checks must be made on enclosures for gaps in fences and holes in flight netting. Cranes must be prevented from escape, particularly if the path to freedom lands a bird in the pen of another. Collisions with power lines and other man-made structures could be lethal for the full-winged escapee and many wild cranes have met this fate (Tacha et al., 1979.)

When putting birds together to creat new pair bonds or small flocks of subadults, it is usually our policy to put all birds into a new pen, rather than introduce a bird into a pen where one or more individuals are already established. The birds should be carefully and frequently observed to ensure compatability, with several food and water stations available. Most deaths due to aggression can be prevented by observant, attentive aviculturists. At ICF's new facility, the disign of the Johnson Exhibit Building is such that accidental entry of individual birds into neighboring pens should not occur. Pairs and incompatable birds are well isolated from one another both visually and physically, and all flight netting is secured at several intervals to guy wires dissecting the pens.

Injury and accident manifest themselves in many ways. Of the fracture type injuries experienced by ICF's cranes, most of them were the result of birds flying into fences. Our practice is to leave full-winged only those males who are well paired and copulate on their own. This means that aviculturists must keep close watch on all other full-winged birds to ensure that one wing is kept clipped at all times. The critical period then, is during the molt when clipped primaries are replaced by complete ones. Young birds at fledging age are particularly vulnerable to collision type injuries because they frequently try out their wings before the feathers are ready for clipping. Our chick exercise corral is not flightnetted and when these fledglings have to be transferred to shelters at the end of the day, each bird must be chased and caught by hand. The corral is only 1.2 meters tall, a distance easily cleared by a frantic crane attempting to escape. The potential for injury is therefore quite high. The most recent fatality from a broken neck was a postfledged chick released into an enclosure before its wings were clipped.

Other accident type injuries that can be avoided are those where cranes have gotten caught on some structure in their pen and in trying to work themselves free, sustain a fatal injury. All loose ropes (for guillotine doors) must be tightly secured, gaps between doors and walls eliminated, and flapping netting (used to create visual barriers) fastened securely to fences. At ICF's present site, Christmas trees line the inside of some cranes pens during the breeding season. The purpose of this is to create "padded" corners to catch cranes for artificial insemination and for further isolation from neighbors. Wing and bill injuries from the chain link fence are thus prevented. These trees must be tightly secured to the fences so that the birds cannot be caught behind them. In the Johnson building, Christmas trees should not be needed because solid walls prevent pairs from seeing and fighting with each other. Only those pairs requiring artificial insemination will need trees in one corner of their pen.

Artificial insemination (Russman 1979, Gee & Temple 1978), and the chick-rearing program at ICF (Lodahl 1978), require that we handle the cranes more than if they were merely being exhibited for educational purposes. When any crane, regardless of age, is physically restrained, it usually has the tendency to kick with its feet, and the chances of it inflicting injury to itself are very great. Fortunately, we have had only one crane, an adult, female Sandhill, die from self-inflicted injury when she cut her jugular vein with her claw. She had been picked up by her humeri and in kicking out with her feet, cut her neck. Anyone who has handled cranes must realize the potential danger of the sharp crane claws and should handle the birds in such a way that struggling be kept to a minimum with the feet kept as far from the body as possible or folded tightly against it.

The sudden attack of raccoons on the cranes required the staff at ICF to develop an effective predator prevention program. After the first crane, a Whooping Crane, was killed, we took immediate action to prevent further visits by racoons. The combination of a late spring and scarcity of food may have forced the raccoons to exploit a new food source, because, although raccoons have always been evident around the crane pens, they had never before posed such a problem. They went to great lengths to obtain crane meat. The presence of humans around the crane pens at night, flight netting, radio voices, and a quickly constructed electric fence did not deter them. No more deaths occurred after the installation of 2 more effective electric fences. One of these consisted of two electric wires circumscribing the bird unit 2.4m off the ground. The other was a 1m tall electrified mesh netting placed all around the unit at a distance of 6m. Of all the suggestions received concerning the deterence of predators from the crane pens, these two fences seemed to be the most effective. As added security, the cranes were locked into their shelters each night. One Demoiselle Crane was killed by raccoons in an area of ICF where electric fences could not be installed, so a red-boned coonhound was stationed in a nearby field to keep raccoons away from the pens. While this scheme poses potential risk to the cranes, we had absolutely no problems and the dog performed beautifully. The Johnson building is equipped with electric fence wires similar to the first described.

The most critical incidence of infectious disease was the IBDCV epornitic in 1978 (Archibald & Viess 1978). Since then, no further losses have been attributed to this herpes virus. The Sandhill Crane that had inclusion bodies in its liver showed markedly different symptoms than those exhibited by the IBDCV victims. The disease outbreak, however, resulted in an intensified crane maintenance program that involves careful sanitation practices, adequate food and water stations, more space per bird, and the use of boot disinfectants. Currently, ICF's cranes are housed in three different areas: Area A houses the birds exposed to the IBDCV in 1978, Area B houses all cranes antibody negative for IBDCV, and Area C consists of those cranes recently transferred to the Johnson building following a three month quarantine against IBDCV. Aviculturists are required to shower and change clothes before going from Area A to Areas B and C, and from Area B to Area C. These procedures should not only be effective in reducing transmission of the IBDCV, but are excellent preventive measures against other infectious agents as well.

Aspergillosis was the second major cause of infectious disease mortality; our efforts to preclude it consist of cleaning out all wet food and bedding daily, raking up grass clippings after lawns have been mowed, and eliminating stress on the birds in every way possible.

Caring for sick cranes, as for any sick animal, requires a fair amount of expertise that only comes with hands-on experience as situations arise. The use of antibiotics and carefully supervised force-feeding programs is one means of treating birds and we have had good success with this. The future holds much in store for ICF's medical program with plans for radiological and surgical facilities as well as a laboratory for on-site projects.

While nutritional myopathy (vitamin E and selenium deficiency) was the primary factor in the death of only one crane, it appeared as a contributing factor in several other cases. The x-rays of a young Siberian Crane's hock joints showed a lack of ossification that is probably nutrition related. However, bone analysis was not performed at the time of death so it is unclear what may have caused this. The bird was isolation-reared in a pen that may not have had adequate sunlight. Nutrition plays a critical role in the growth, health, and reproduction of any organism and it is essential that formulated diets provide all the necessary nutrients in the proper amounts. Feed storage and provision of vitamins and minerals are also important in the feeding program, as the viability and food value of ingredients decreases with time (Russman & Putnam 1980). Effort should be made to use the freshest food possible, but this is becoming increasingly difficult with feed companies that require large orders. A solution is to divide feed orders among other crane centers but this is both expensive and inconvenient.

Anatomical abnormalities are usually difficult to correct but ICF has had considerable success correcting growth-related problems in young birds through the use of leg braces, increased exercise, and food monitoring (Archibald & Viess 1979). Initial prevention of these problems comes through the development of better management programs; various factors that contribute to anatomical disabilities have been identified by officials at PWRC (Carpenter et al. 1976). Further observations on natural rearing of crane chicks by their parents or foster parents must be made to ascertain if these chicks have fewer growth problems than hand reared chicks. Of two parent reared chicks at ICF, one Common Crane developed serious leg bowing and had to be taken from its parents and treated until fledging. The other, a Hooded Crane, had no problems. In the Johnson building, pairs may have the opportunity to raise their young, so we will be able to collect more data on this.

The primary mortality factors for the birds that died during, or shortly after, anaesthetization are difficult to pinpoint. Each case was unique and decisions had to be made as to whether or not the risk of the operation exceeded the risk of using anaesthetics. The stresses placed on cranes with broken femurs are numerous, regardless of anesthetic use, and we have had little success with such injuries. Even with limited mobility through the use of slings, casts, and other restraints, and constant supervision, cranes have failed to survive.

The northern crane species, exposed to similar climatic conditions in their native habitats, have been fairly capable of adapting to Wisconsin's winters. The southern species require protection from the cold and frosts, so at ICF we provide them with thick layers of wood shavings and indoor stalls. Problems range from frozen toes which eventually fall off, to the loss of entire limbs, leading to systemic infection and impaired locomotion. To further protect these species, the Johnson building is equipped with heat lamps and heated floor pads in addition to the indoor stalls and thick sand bedding.

From this report it is evident that many improvements have been made in crane husbandry to minimize mortality. This discussion has centered around many deaths that could be considered avoidable and taking these into consideration ICF's new exhibit unit has been designed such that repetition of these should not occur. Two major bouts of mortality for which we were relatively unprepared were the IBDCV epornitic in 1978 and the raccoon predation incident in 1982. Our techniques for crane rearing have improved as a result, and special attention has been given to these potential threats, to further discourage any recurrence of the virus or predator attacks. Hindsight is not the only way to prevent mortality, though, and aviculturists should always be aware of potential threats. In the past, vandalism and parasitism are two types of mortality we have not experienced but have occurred at other animal facilities. Continued annual health checks provide the opportunity to examine thoroughly each bird individually, take blood samples, and swab them for virological, bacterial, and parasitic evaluations. These services have been performed in the past by the NWHL and the University of Wisconsin-Madison Veterinary Science Department, and the importance of this work cannot be emphasized enough.

Shipping cranes to other crane centers is something we are beginning to incorporate into our program. Great risks are involved, particularly when the shipping crates are handled by people unfamiliar with animal transfer procedures.

Cranes may become stressed very easily when exposed to new and unusual situations or when their normal environment and routine are disrupted by the presence of people or foreign objects. With ICF's increased publicity, more and more people are becoming interested in cranes. Previously, tours have been guided and well chaperoned, with much attention to visitors. With expansion, tours will be self-guided, and visitors will wander more freely on the premises. There is the risk that foreign objects may be tossed into the pens. Cranes are very curious, and the ingestion of metal objects can cause serious damage to their digestive tracts, possibly ending in death (Bush & Kennedy 1978). People may get too close to the birds. Even the photographer who merely wishes to photograph without the obstruction of the chain link fence can cause a bird to become stressed. One of the Whooping Crane deaths was brought about by a group of hot air balloons idly drifting over the crane pens. Of course no harm was meant by this, but the crane became hysterical and broke its bill on the fence. A leg fracture followed during a force-feeding session and the bird died soon after that. Not only do we have to be concerned about the presence of people on the site during visitor hours, but those in the area, or seemingly remote from the facility, after visitors have gone. The remoteness of ICF's new facility may invite unauthorized individuals to wander in and unintentionally or intentionally cause harm to the cranes. The paved parking lot and path around the crane pens have already elicited the antics of children on bicycles and this type of activity must be discouraged at all times. Plans are in store to have a person permanently stationed at the new site to help prevent unauthorized visits.

CONCLUSION

The concerted efforts of everyone working with cranes can help reduce mortality at crane centers throughout the world. Studies on causes of mortality and prevention methods (both medical and technical) are extremely valuable not only to the organization conducting the study, but also to other crane aviculturists as well. Of perhaps even greater importance is the contribution to protection of wild crane populations that studies of captive crane diseases can provide. The prevention of mortality for captive cranes will help give a better understanding of the successful management of wild cranes. Aviculturists and crane specialists need to take advantage of their experience, pool resources and ideas, and share information among themselves to help minimize the losses of captive cranes.

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CYTOLOGICAL SEX DETERMINATION IN CRANES

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ABSTRACT

Sexing of young cranes by the feather pulp cytological method has several advantages over both fecal steroid analysis and laparoscopy, notably that it is 100% reliable at any age and is minimally invasive to the animals. Specimens of *Grus vipio* and *Grus americana* were easily sexed from culture of single feathers. In addition, chromosome banding techniques revealed differences between these species that have arisen since their common ancestor. However these chromosome changes have been very minor, a characteristic common to most bird taxa.

There are generally acknowledged to be 3 major methods for determining the sex of monomorphic birds: (1) Laparoscopy, which involves the insertion of an optical sighting device into the abdominal cavity for direct viewing of the gonads, (2) Fecal steroid analysis, based on the differential levels of hormones in males and females as reflected in fecal samples, and (3) Cytological sexing, based on the strict determination of sex by chromosomes that differ in constitution between the two sexes (Bercovitz, 1982). Method (1) is often associated with damage to the extensive air sac system of birds, and at the very worst can result in death from trauma. Method (2) is noninvasive but cannot be applied to very young birds in which the sexes have not yet differentiated sufficiently with regard to sex hormones. This is a disadvantage when it is desirable to pair up potential future mates at an early age.

The first two methods have a reliability less than 100%, whereas cytological sexing is 100% reliable at any age, provided that the sex chromosomes are successfully located (Bercovitz, 1982). This is because gonadal tissues as well as steroid hormones exhibit variability, such as that due to age, that occasionally leads to erroneous results. The chromosome constitution, however, is the primary determinant of sex in birds and is invariate in cells from the time of fertilization until death.

Interestingly, not all vertebrates have the same means of determining sex. In some turtles sex is determined by ambient temperature during egg incubation and hatching (Morreale et al., 1982; Bull and Vogt, 1979). Sex can therefore be "chosen" by selecting the correct temperature for hatchlings (Morreale et al., 1982). All mammals and birds, however, have evolved sex determination by sex chromosome inheritance, but with some differences between them. Male mammals possess one X and one Y (male determining) chromosome, while females have 2 X's. The situation is reversed in birds, where males have 2 Z chromosomes and the females have one Z and one W (Mengden and Stock 1976). Since male mammals and female birds have both kinds of sex chromosomes, the males are responsible for the sex of offspring in mammals, but females are responsible for sex of offspring in birds. Clearly sex determination evolved independently in birds and mammals since the time they shared a common reptilian ancestor in the Mesozoic over 150 million years ago.

In birds as in mammals, the two kinds of sex chromosomes usually have different sizes and characteristics, making their identification straightforward (Mengden and Stock, 1976). The Z chromosome is generally about third or fourth largest in size, while the W is considerably smaller and often in the same size class as the numerous "microchromosomes" that most birds possess. A specific chromosome staining method called "C-banding" reveals unique, darkly stained chromosomal areas called "heterochromatin" which are often present in a conspicuous block on the W chromosome of females (Stefos and Arrighi, 1971). Thus, the results of conventional staining to determine size of sex chromosomes can be confirmed by C-banding for heterochromatin on the W.

The primary requirement for visualizing the chromosomes is obtaining cells that are in division, when the chromosomes are most condensed and visible. Dividing cells have been obtained from many tissues that exhibit regeneration including skin, blood, kidney, lung, and feather pulp. We have found feather pulp to have several obvious advantages over these other tissues: it is the least invasive to collect, yields more dividing cells than blood, and can be used for young birds where blood drawing may be impractical or harmful (van Tuinen and Valentine, 1983). The pulp can either be squashed on a slide directly, then stained, or it can be grown in a tissue culture laboratory to obtain large numbers of cells of hetter quality. We have chosen the latter method for the greater reliability and the advantages it has in research.

Briefly, a growing feather is plucked carefully and 2.5cm of the insertion end is cut open to expose the soft, actively dividing tissue. The tissue is treated with collagenase to separate many of the viable cells, and these are then placed in a tissue culture vessel with growth medium to support growth. After 10-14 days of careful feeding and microscopical observation the many dividing cells can be dislodged from the dish, treated so as to obtain optimum chromosome quality, and spread on slides for staining and analysis. The same or next day C-banding can be done to confirm the results of gross visual inspection.

We have sexed and studied a female White-naped Crane (*Grus vipio*) and a male Whooping Crane (*G. americana*) from the International Crane Foundation, Baraboo, by this method. The differential size and heterochromatin staining of the sex chromosomes is clear, and sexing was unambiguous. In addition to the primary goal of sexing these cranes, chromosome analysis in our lab and other labs has revealed several interesting facts of evolutionary interest concerning cranes. It is known that the chromosomes of birds have evolved very much more slowly than chromosomes of mammals, and thus the chromosomes of birds even in different orders are often similar (Takagi and Sasaki, 1974; Stock and Mengden, 1975). This might be responsible in part for the successful and fertile crossing of birds of different species.

Sasaki and Takagi and coworkers report that the gross morphology of the chromosomes of 12 crane species studied is very similar (Takagi and Sasaki, 1974; Sasaki and Takagi, 1981). Detailed chromosome banding analysis revealed that the Great Bustard (*Otis tarda*) (also of the order Gruiformes), has chromosomes similar to those in *Grus* (Nishida et al., 1981). Our comparison of *G. americana* and *G. vipio* shows almost total similarity in the large, analyzable chromosomes. Several minor differences exist in the distribution of heterochromatin (C-bands) between them, mainly on the tips of chromosome 1 and the centromere (constriction) of the Z (*Fig. 1*). These sorts of differences are very common in vertebrate species and are probably not important genetically, since this heterochromatin is generally thought to be "junk DNA" that has no indispensable function (John and Miklos, 1979). In any case, it points out some interspecific differences that arose since these two species separated evolutionarily.

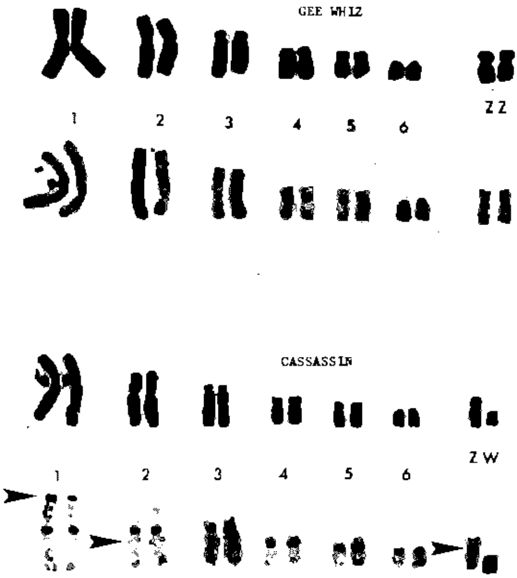

Figure showing chromosomes of *Grus americana* (top,♂) and *G. vipio* (bottom,♂). C-banding demonstrates dark heterochromatin on the W, as well as its small size. Some differences between these two species are evident in the C-bands of chromosomes 1, 2, and Z (arrows). The conventionally stained cell of "Cassassin" is shown at bottom left before cutting, showing numerous microchromosomes.

Fig. 1. The largest seven pairs of chromosomes are shown from the male Whooping Crane (top) and the female White-naped Crane (bottom). The only detectable differences between their chromosomes are the areas of heterochromatin on chromosome 1 and at the centromere of the Z. Note the heavily heterochromatic W in the White-naped Crane, confirming the sex as female.

Unfortunately, the technique we used to perform the sexing requires a reasonably well outfitted chromosome laboratory. We are currently working on a reliable direct squash method that would eliminate the need for expensive tissue culture equipment, medium for growing, etc. In this way results would be available immediately and even simple laboratory facilities would be adequate for determining sex. It may be sufficient simply to attempt several squashes until satisfactory results are obtained. We hope to be able to report improvements in this direction soon.

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BIOCHEMICAL SYSTEMATICS AND EVOLUTION OF THE CRANES (AVES: GRUIDAE)

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ABSTRACT

Fourteen species of cranes were analyzed using starch gel electrophoresis in order to elucidate systematic relationships. Twenty-one presumptive genetic loci were consistently resolvable. In a phenogram based on Nei's unbiased genetic identity, the two species of *Balearica* clustered together and apart from the other genera. The two species of *Anthropoides*, however, were widely separated within the cluster. The relationships within *Grus* were similar to those found by other investigators. *Grus leucogeranus* is more similar electrophoretically to *Grus americana* than it is to *Bugeranus carunculatus*, a species to which it appears similar using skeletal and behavioral characters.

INTRODUCTION

The cranes (Aves: Gruidae) are a widely distributed group that recently have been increasingly studied because many of the natural populations are endangered. The United States government currently considers six species and two subspecies of a seventh as endangered (Federal Register, 45 (99), 1980). Most of the problems are due to habitat degredation and heavy hunting pressure.

As is true of most avian groups, systematic studies of the cranes have been restricted to morphological characters such as feather color or skeletal features (Wood, 1979). However, Archibald (1976) added a behavioral component to the systematics of this group with his study of the unison call, part of the courtship display. Biochemical systematic studies of avian species using electrophoretic techniques have multiplied in recent years (Avise et al., 1980a, 1980b, 1980c, 1982 and references therein). Morgan et al. (1977) performed the only electrophoretic analysis of cranes; they studied serum proteins and esterases of three subspecies of Sandhill Cranes (*Grus canadensis*) and did not find intraspecific differentiation.

Peters (1934) recognized 14 species of cranes in four genera. However, more recent systematic treatments of this group listed 15 species (Walkinshaw, 1973; Wood, 1979). Examination of both Peters' and Archibald's taxonomic schemes (*Fig. 1*) indicates that *Grus leucogeranus* clusters with the genus *Bugeranus* and not with *Grus*. Wood (1979) found *Grus leucogeranus* to be very similar to *Grus americana* in external features but more similar to *Bugeranus carunculatus* in skeletal features. Wood (1979) attributed the similarity between *Grus leucogeranus* and *Grus americana* to convergence resulting from selection in similar ecological niches. Wood (1979) suggested that *Grus leucogeranus* should be moved to the genus *Bugeranus*. The correct taxonomic position of *Grus leucogeranus* is of intense interest to crane biologists (Archibald, pers. comm.). In an attempt to elucidate systematic relationships among cranes, we performed an electrophoretic analysis of representatives from 14 nominal taxa.

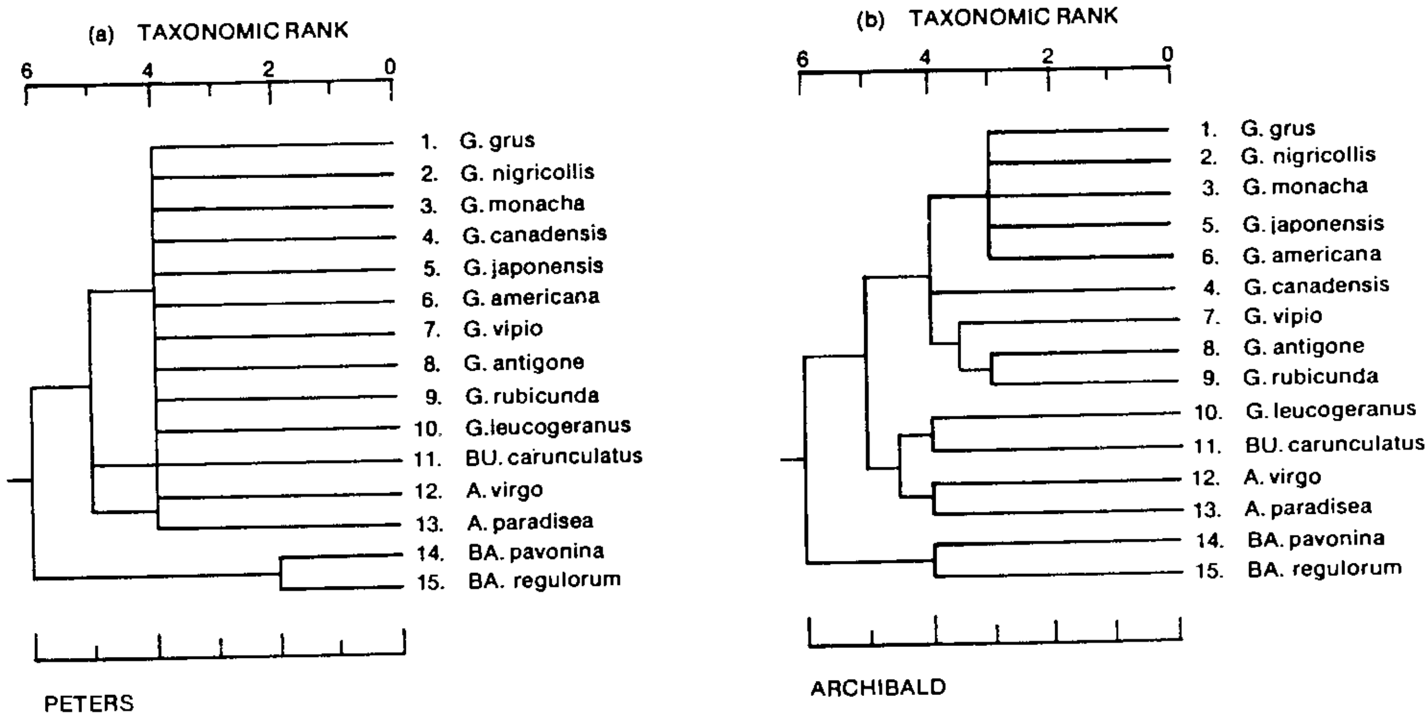

Fig. 1. Phenograms representing the classification of cranes as proposed by Peters (1934) and Archibald (1976); redrawn from Wood (1979).

METHODS AND MATERIALS

Blood (10ml) was collected from two individuals of 13 species of cranes (*Table 1*) and from four individuals of *Grus americana*. Blood from *Grus americana* was obtained from the captive breeding flock at the Patuxent Wildlife Research Center, Laurel, Maryland. Samples from the other species were collected from the captive breeding flock at the International Crane Foundation (ICF), Baraboo, Wisconsin by J.L. Ingold and ICF personnel.

Upon collection, blood was centrifuged at 3,000rpm for 10 minutes, the plasma decanted, and frozen at -75°C. The pellet was washed three times in avian saline, mixed with a volume of avian saline 3x the volume of packed cells, frozen, thawed, shaken vigorously and then centrifuged at 3,000rpm for 10 minutes. The red cell hemolysate was decanted and kept frozen at -75°C. The pellet containing the nuclei was frozen at -75°C for use in DNA-DNA hybridization studies to be conducted.

The horizontal starch gel electrophoretic techniques and recipes of Selander et al. (1971) were employed in conjunction with the staining procedures of Brewer (1970). The following 18 presumptive genetic loci were consistently resolved from the red cell hemolystate: lithium hydroxide buffer — glucokinase (GK), leucine aminopeptidase (LAP-1), and superoxide dismutase (SOD-1, -2); tris-citrate buffer (pH 8.0) — catalase (CAT), lactate dehydrogenase (LDH), phosphoglucomutase (PGM-1, -2) and peptidases (D-leucyl-L-tyrosine) (PEP-1, -2); Poulik buffer — esterases (EST-1, -3); Clayton-Tretiak buffer — hemoglobin (Hb), malate dehyrogenase (MDH-1, -2), phosphoglucose isomerase (PGI); tris-citrate buffer (pH 6.0/6.7) — mannose phosphate isomerase (MPI); tris-HCl buffer (pH 8.5) — 6 phosphogluconate dehydrogenase (6-PGDH). The following three presumptive genetic loci were consistently resolved from plasma with lithium hydroxide buffer: albumin (ALB), leucine aminopeptidase (LAP-2), and non-specific protein (TP). A matrix of Rogers' (1972) genetic similarity and Nei's (1978) unbiased genetic identity values was generated from the electrophoretic data. Cluster analysis of this matrix was performed with the unweighted pair-group method with arithmetic averaging (UPGMA) using the BIOSYS-1 program (Swofford and Selander, 1981).

RESULTS

Intraspecific genetic variation occurred at only three of 21 (14 percent) loci sampled (PGM-1, PGM-2, and 6-PGDH), all variants were heterozygotes. Within the family, nine of 21 (43 percent) loci sampled were polymorphic (*Table 2*).

A matrix of Rogers' S (1972) and Nei's unbiased genetic identity (1978) is presented in *Table 3*. A phenogram based on the genetic identities (*Fig. 2*) has a cophenetic correlation coefficient of 0.94. Although the two species of *Balearica* cluster together as one would expect, the remaining three genera are found in one major cluster. Especially notable is that the two species of *Anthropoides* are widely separated within this cluster. *Anthropoides virgo* is electrophoretically identical to *Grus leucogeranus* for the loci examined, whereas although not identical, *Anthropoides paradisea* clusters with *Bugeranus carunculatus*. *Grus canadensis*, *Grus rubicunda*, and *Grus vipio* are electrophoretically identical and are found in a cluster with *Grus antigone*. When the genetic identities (*Table 4*) and the similarities (*Table 5*) are averaged by genus, the intergeneric relationships seen within the phenogram are made clearer. *Bugeranus* is more similar to the two species of *Anthropoides* than those two species are to each other. The lowest similarity and identity values occur in the comparison of *Balearica* to the other three genera.

DISCUSSION

The systematic relationships of cranes as determined by electrophoresis are not in total agreement with the morphological (Wood, 1979) or behavioral (Archibald, 1976) data nor

Table 1. Crane species of the world used in analysis, their present geographical distribution, and their endangerment status.

Name (a)	Current (b) Distribution	Endangerment (c) Status
1. *Anthropoides virgo* Demoiselle Crane	Africa, Asia	
2. *Anthropoides paradisea* Stanley Crane	Africa	
3. *Bugeranus carunculatus* Wattled Crane	Africa	
4. *Balearica pavonina* West African Crowned Crane	Africa	
5. *Balearica regulorum* South African Crowned Crane	Africa	
6. *Grus antigone* Sarus Crane	Asia, Australia	
7. *Grus japonensis* Japanese Crane	Asia	Endangered
8. *Grus leucogeranus* Siberian Crane	Asia	Endangered
9. *Grus monatcha* Hooded Crane	Asia	Endangered
10. *Grus canadensis* Sandhill Crane	North America, Cuba	Endangered (*G.c. nesiotes*) (*G.c. pulla)*
11. *Grus grus* European Crane	Eurasia	
12. *Grus rubicunda* Brolga	Australia	
13. *Grus vipio* White-naped Crane	Asia	Endangered
14. *Grus americana* Whooping Crane	North America	Endangered

(a) Species names from Peters (1934) and Walkinshaw (1964); common names from Walkinshaw (1973).
(b) Distributions from Walkinshaw (1973).
(c) Endangerment status from the Federal Register, Vol. 45 (99), May 1980.

with the accepted classification of Peters (1934, *Fig. 1*). *Balearica*, the crowned crane group, is the only one consistently clustered as a distinct lineage by all alternative techniques of determining relationships. This genus is the most primitive of the modern species based on the fossil record (Brodkorb, 1967).

The remaining species, comprising three genera, form one major cluster. The most unusual aspect of this cluster is the placement of the two species of *Anthropoides*. While in other studies they always cluster together, here they are widely separated; *Anthropoides virgo* is electrophoretically identical to *Grus leucogeranus* while *Anthropoïdes paradisea* clusters with *Bugeranus carunculatus*. Externally these two species are most similar in regards to their small size, especially the relatively small beak, a character they share with

Table 2. Allelic frequencies observed in Gruidae.(a)

Protein locus	Species(b)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GK														
A					100									
B	100	100	100	100			100	100			100			100
C						100								
D									100	100		100	100	
MPI														
A		100	100											
B	100			100	100	100	100	100	100	100	100	100	100	100
PEP-1														
A				100										
B	100	100	100		100	100	100	100	100	100	100	100	100	100
PEP-2														
A	100	100	100			100		100		100		100	100	100
B				100	100									
C							100		100		100			
6-PGD														
A	100	100	100	100	100	100	100	100	100	100	100	100	100	75
B														25
PGM-1														
A		50		50										50
B	100	50	100	50	100	100	100	100	100	100	75	100	100	50
C											25			
PGM-2														
A	100	100	100	100	100	100	100	100	50	100	100	100	100	100
B									50					
SOD-1														
A	100	100	100			100	100	100	100	100	100	100	100	100
B				100	100									
SOD-2														
A	100	100	100			100	100	100	100	100	100	100	100	100
B				100	100									

(a) All species were monomorphic for the same electromoph at CAT, EST-1, EST-3, HB, LDH, LAP-1, LAP-2, MDH-1, MDH-2, PGI, ALB, and

(b) Species are numbered as in *Table 1*.

Table 3. Genetic similarities (above diagonal; Rogers 1972) and genetic identities (below diagonal; Nei 1978) between species of cranes, based on electrophoretic analysis at 21 loci.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Demoiselle Crane	-	0.929	0.952	0.786	0.810	0.952	0.952	1.000	0.881	0.952	0.940	0.952	0.952	0.964
2. Stanley Crane	0.944	-	0.976	0.762	0.738	0.881	0.881	0.929	0.810	0.881	0.884	0.881	0.881	0.940
3. Wattled Crane	0.952	0.992	-	0.738	0.762	0.905	0.905	0.952	0.833	0.905	0.893	0.905	0.905	0.917
4. West African Crowned Crane	0.798	0.762	0.750	-	0.881	0.738	0.786	0.786	0.714	0.738	0.789	0.738	0.738	0.798
5. South African Crowned Crane	0.810	0.750	0.762	0.895	-	0.810	0.810	0.810	0.786	0.810	0.798	0.810	0.810	0.774
6. Sarus Crane	0.952	0.895	0.905	0.750	0.810	-	0.905	0.952	0.881	0.952	0.893	0.952	0.952	0.917
7. Japanese Crane	0.952	0.895	0.905	0.798	0.810	0.905	-	0.952	0.929	0.905	0.988	0.905	0.905	0.917
8. Siberian Crane	1.000	0.944	0.952	0.798	0.810	0.952	0.952	-	0.881	0.952	0.940	0.952	0.952	0.964
9. Hooded Crane	0.895	0.836	0.847	0.738	0.798	0.895	0.944	0.895	-	0.929	0.917	0.929	0.929	0.845
10. Sandhill Crane	0.952	0.895	0.905	0.750	0.810	0.952	0.905	0.952	0.944	-	0.893	1.000	1.000	0.917
11. European Crane	0.952	0.900	0.904	0.802	0.807	0.904	1.000	0.952	0.943	0.904	-	0.893	0.893	0.920
12. Brolga	0.952	0.895	0.905	0.750	0.810	0.952	0.905	0.952	0.944	1.000	0.904	-	1.000	0.917
13. White-naped Crane	0.952	0.895	0.905	0.750	0.810	0.952	0.905	0.952	0.944	1.000	0.904	1.000	-	0.917
14. Whooping Crane	0.988	0.955	0.939	0.806	0.793	0.939	0.939	0.988	0.880	0.939	0.945	0.939	0.939	-

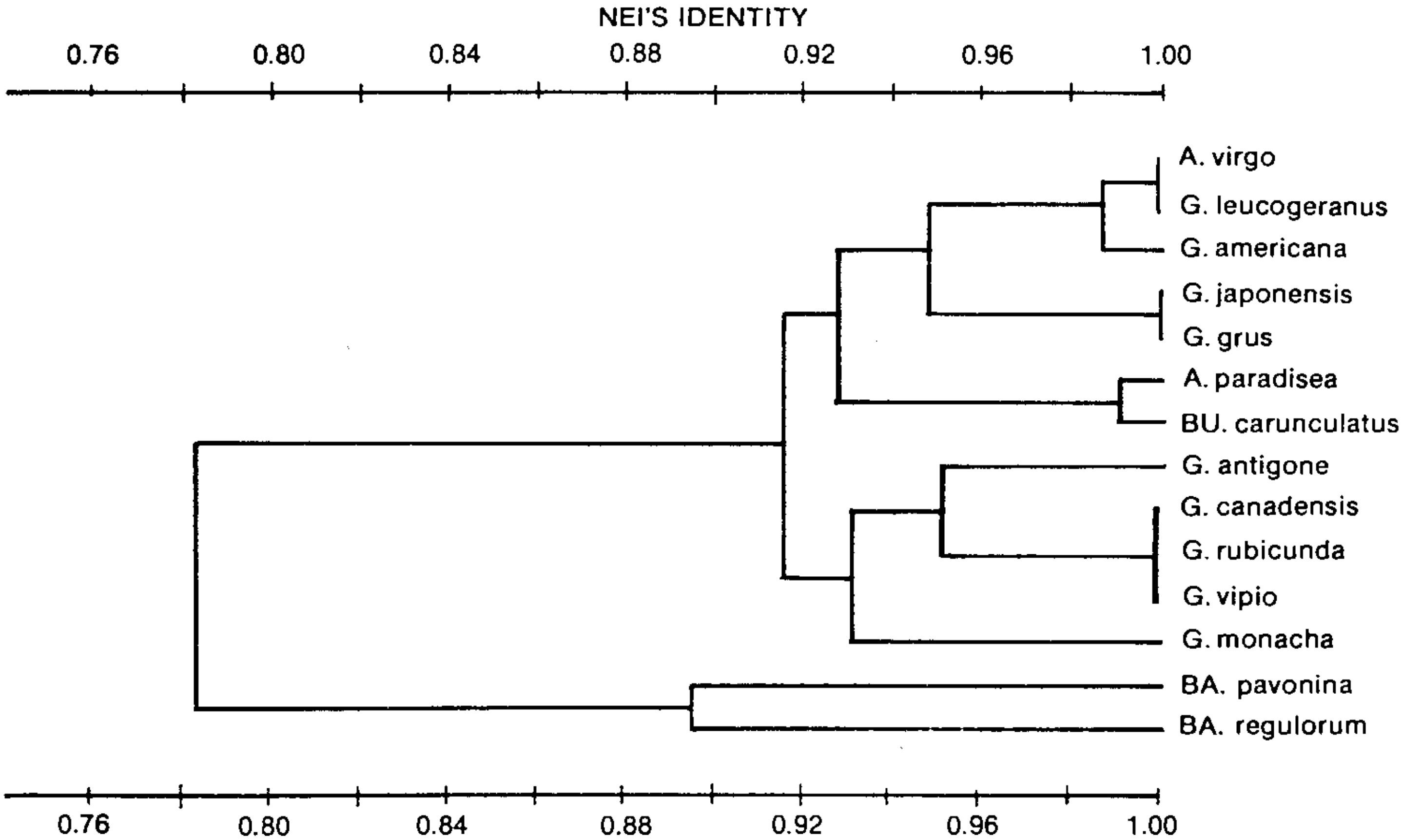

Fig. 2. Phenogram for crane species using Nei's (1978) unbiased genetic identity.

Table 4. Nei's (1978) unbiased genetic identities averaged by genus.

Genus	Number of Populations	1	2	3	4
1. *Anthropoides*	2	0.944 (0.944-0.944)			
2. *Bugeranus*	1	0.972 (0.952-0.992)	* *		
3. *Balearica*	2	0.780 (0.750-0.810)	0.756 (0.750-0.762)	0.895 (0.895-0.895)	
4. *Grus*	9	0.928 (0.836-1.000)	0.907 (0.847-0.952)	0.789 (0.738-0.810)	0.940 (0.880-1.000)

* Only one population included.

Table 5. Rogers' (1972) genetic similarities averaged by genus.

Genus	Number of Populations	1	2	3	4
1. *Anthropoides*	2	0.929 (0.929-0.929)			
2. *Bugeranus*	1	0.964 (0.952-0.976)	* *		
3. *Balearica*	2	0.774 (0.738-0.810)	0.750 (0.738-0.762)	0.881 (0.881-0.881)	
4. *Grus*	9	0.918 (0.810-1.000)	0.902 (0.833-0.952)	0.780 (0.714-0.810)	0.929 (0.845-1.000)

* Only one population included.

the crowned cranes. Although they show some affinities to *Grus canadensis* in their unison call, electrophoretic data indicates they are not closely related.

One of the most interesting taxonomic questions within the Gruidae is the systematic relationship of *Grus leucogeranus*. Its skeletal morphology and unison call are very similar to *Bugeranus carunculatus*. However, analysis of external characters relate it to *Grus americana*. The electrophoretic data demonstrate that *Grus leucogeranus* is biochemically identical to *Anthropoides virgo* and very similar to *Grus americana*. Althouth it appears within a major cluster with *Bugeranus* it is still very distinct from that species.

Archibald (1976) used the unison call to examine the relationships within *Grus* and placed the eight species that he studied into three groups. Group I contained only *Grus canadensis*, Group II was composed of *Grus antigone*, *Grus rubicunda*, and *Grus vipio*, while Group III had *Grus monacha*, *Grus grus*, *Grus americana*, and *Grus japonensis*. Electrophoretic data indicate that these species of *Grus* form two major clusters. One cluster contains Archibald's Groups I and II with the addition of *Grus monacha* while the other major cluster contains *Grus grus*, *Grus americana*, *Grus japonensis*, and *Grus leucogeranus*. In Archibald's study, *Grus leucogeranus* was not placed in *Grus* but clustered with *Bugeranus*.

Systematic studies of animals historically have been limited to analyses of morphology. However, to obtain a complete picture of relationships, a variety of techniques must be employed. The cranes as a group have been studied extensively in regards to their taxonomic relationships: external morphology and skeletal systems (Wood, 1979); behavior (Archibald, 1976); chromosomal karyotyping (Shields, 1982). Our analysis has added a biochemical component. Chromosome counts documented that the seven species studied to date have identical diploid chromosome numbers of 82 (Shields, 1982); therefore, this information is not useful in determining systematic relationships. However, the behavioral, morphological and biochemical data have provided variation that can be used to make some systematic comparisons. The behavioral and morphological data are very similar to one another while the biochemical data are quite different.

In dealing with the differences in relationships of cranes based on our data and those of Wood (1979) and Archibald (1976), we must decide which are the better or more conservative. It is well established that the enzymes used in electrophoretic studies are encoded by single structural gene loci whereas morphological and behavioral characters may be polygenic. Polygenic characters such as these are more readily altered by environmental and ecological conditions and therefore convergences in these characters are more likely to occur. Enzyme evolution is known to be conservative, especially so in birds (Aquadro and Avise, 1982). Therefore, the systematic relationships presented in this paper based on electrophoretic data can be considered to be a reliable estimate of relationship. The great disparity between the morphological and electrophoretic data demands that further systematic studies be conducted. Two other biochemical techniques are available to further elucidate systematic problems in the Gruidae. We have recently begun studies of crane systematics using DNA-DNA hybridization and plan microcomplement fixation analysis in the near future.

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WEIGHT LOSS AND EGG SHELL THICKNESS OF CRANE EGGS

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ABSTRACT

Section 1 - The percent weight losses for artificially incubated Red-crowned, White-naped, Sarus and Siberian Crane eggs from 1981 were analyzed and compared with data from 1980 (Rogers 1981). The results of the 1981 and 1982 studies were analogous: eggs in various states of fertility were not significantly different in their total percent weight losses, the total percent weight losses for four species of cranes were not significantly different, no strong correlations were found between an eggs' initial weight and its total percent weight loss, and an eggs' initial weight and its hatchability.

Section 2 - Measurements were taken and analyzed from sixty-four crane eggs to determine the variations in their egg shell thicknesses. Regional variations within each egg were found, with the majority of eggs being significantly thicker in the middle regions. Significant variations in egg shell thicknesses were found among the following levels: 1.) individuals eggs 2.) individual females and 3.) species. The dominant factor in shell thickness variability was the individual female crane.

Section 3 - Possible relationships between egg shell thicknesses, total percent weight loss, percent hatchability and order of egg deposition were examined. No relationships were found between the total percent weight losses and average shell thicknesses. A linear relationship was observed between the order in which eggs were deposited and the thickness of their shells, i.e. the egg shells became progressively thinner with each egg that is laid. Neither hatchability nor total percent weight loss were related to the order of egg deposition.

INTRODUCTION

The total percent weight loss of an egg is dependent on several variable factors: temperature, humidity, air speed around the egg, and egg shell morphology (Rolnik 1970). Temperature, humidity and air speed around the egg are controllable variables when eggs are artificially incubated, whereas an egg shells' morphology can not be directly controlled. In fact, an egg shells' morphology changes throughout incubation when the developing embryo withdrawls calcium directly from the shell (Simkiss 1961). Egg shell porosity and thickness are two morphological components that can be measured directly. In the following study egg shell thickness from six species of cranes were measured and used to look for possible relationships between crane eggs, shell morphology, total percent weight loss, hatchability, and order of egg deposition.

METHODS AND MATERIALS

Section 1

One-way analysis of variance, with equal sample sizes, was used to test variability in total percent weight loss between 1981 and 1976-1980 data from the International Crane Foundation (ICF), in Baraboo, Wisconsin.

Section 2

Sixty-four egg shells from artificially incubated crane eggs were collected from July-August 1981. The egg shells' thicknesses were measured from January-March 1982 and the data was analyzed using one-way analysis of variance, t-tests and orthogonal contrasts. A mitutoyo 0.25mm-0.01mm micrometer, with a curved fitting on the spindle, was used to measure the egg shells' thicknesses. Infertile eggs were pulled from the incubator and stored at normal room temperature. The eggs' fluids were removed from a small hole with a 12cc syringe, after which the inside shell was rinsed with acetone. The eggs were cut in half with a single edged razor blade and soaked in hot water to remove the remaining membranes. Fertile eggs were collected after hatching (28-33 days of incubation) and remaining membranes removed. Each egg was divided into three regions (*Fig. 5*). Ten shell pieces were randomly selected and measured from each region and comparisons made. All shells from the three regions were then mixed together, and twenty pieces randomly selected, measured and averaged. Averages from the twenty shell pieces were used to analyze variations in egg shell thicknesses among 1) individual eggs 2) individual females and 3) species.

Section 3

Linear regression was used to examine the possible relationships between average shell thickness, total percent weight loss, hatchability, and order of egg deposition.

RESULTS AND DISCUSSION

Section 1

Generally, the same conclusions can be drawn between 1976-1980 (Rogers 1982) and 1981 weight loss data from ICF. There is not a significant difference ($P > 0.01$) in total percent weight loss for eggs in different states of fertility, with the exception of an egg from Sauwaka, a Red-crowned Crane (*Table 2**), who has a history of laying eggs with high weight losses (Rogers 1981). A significant ($P < 0.01$) difference for fertile hatched (FH) eggs between Red-crowned, White-naped and Eastern Sarus Cranes is found in *Table 1*. This difference is attributed to the Eastern Sarus eggs' high level of weight loss (*Tables 1,2*). Because Sarus eggs are incubated with Red-crowned eggs and show a 70 percent hatchability rate, it is possible that the observed weight loss differences are related to species variations.

The initial weight of an egg does not appear to affect its hatchability rate (*Figs. 1,2*), while there are general ranges for each species in which their initial weights fall: White-naped Cranes 180-195g, and Red-crowned Cranes 210-225g. (*Figs. 1,2*). It is interesting to note that the eggs which do not fall within these ranges usually have good hatchability rates.

Drent (1975) and Rahn et al. (1979) determined that eggs loose 15-18 percent of their initial weight during incubation. Red-crowned, White-naped and Siberian Crane eggs, from 1976-1981, lost 12-16 percent of their initial weight, while Eastern Sarus eggs lost 17 percent (*Table 2*).

Section 2

There are several factors that contribute to the variability of egg shell thicknesses:

1) Biological-genetic and or physiology differences between females, metabolic rates in

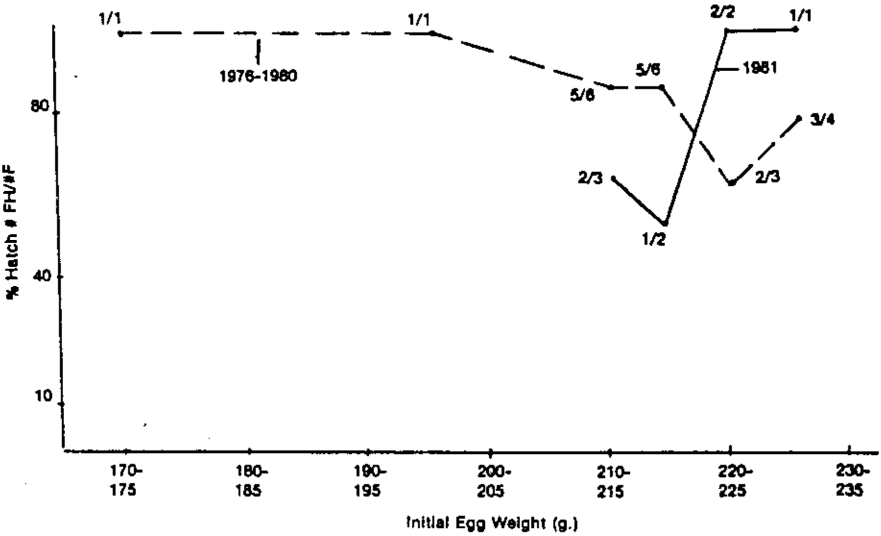

Fig. 1. Percent hatchability as related to initial egg weight for Red-crowned cranes, 1976-1980 and 1981.

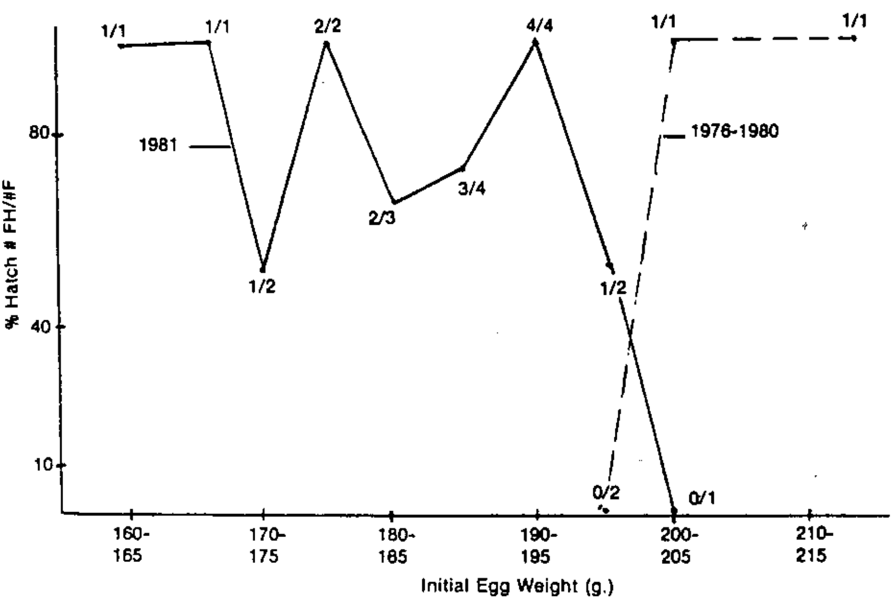

Fig. 2. Percent hatchability as related to initial egg weight for White-naped cranes, 1976-1980 and 1981.

Table 1. One-way ANOVA for the total percent weight loss of fertile hatched F(H) eggs between Red-crowned, White-naped and Eastern Sarus cranes, 1981.

Categories	N	Mean weight loss	F-Ratio	P-Value
Fertile Hatched				
Red-crowned	6	13.08	32.45	P<0.01
White-naped	15	12.65		
Eastern Sarus	7	17.23		

Table 2. Total percent weight loss data for F(H), F(D) and I eggs from White-naped, Red-crowned, Siberian and Eastern Sarus cranes, 1976-1981.
* n=2 Sauwaka: + n=1: ● n=2.

		Total Percent Weight Loss			Total
Species	Year	F(H)	F(D)	I	76-81
White-naped	1976	9.3	—	9.5	
	1979	9.6	10.7	11.6	
	1980	—	12.9	14.1	12.2
	1981	12.7	13.5	12.6	
Red-crowned	1976	12.4	—	12.9	
	1977	11.6	—	9.4	
	1979	12.1	—	13.0	13.2
	1980	13.8	13.6	12.7	
	1981	13.1	17.8*	13.9	
Siberian	1981	21.1+	19.6●	11.9	14.6
Eastern Sarus	1981	17.2	17.2	17.7	17.3

the females and/or embryos, different stages of incubation, clutch size, and order in which eggs are deposited. 2) Human imperfections in measuring devices, human error (Klass, Ohlendore and Heath 1974, Capen 1977). Variations due to human error were minimized as much as possible. However, I feel the wide range of variability seen in the data is partially due to the sampling techniques (see methods and materials). Some of the variability could have been reduced if: 1) three to five measurements were taken from each eggs' midsection, instead of 20 measurements from the entire egg (Capen 1977, Berg 1945, Anderson & Hickey 1970 and Rothstein 1972), 2) eggs were collected and measured before incubation and the subsequent thinning of egg shells due to the embryos' metabolization of the shells' calcium (Simkiss 1961). It is important to remember the sampling techniques used when analyzing the data.

One-way analysis of variance with equal sample sizes was used to find a significant ($P < 0.01$) difference between regions 1, 2, and 3 within an individual egg. 55 percent of the eggs are significantly thicker in region 3, 28 percent do not show any regional variations, and 17 percent are significantly ($P < 0.01$) thicker in region 1. Egg shell thicknesses do not vary significantly within each region.

Berg (1945) measured the various relationships between clutches and egg shell quality. He finds a significant amount of variation exists in eggs laid by the same female. Klass, Ohlendorfe and Heath (1974), looked at variations in egg shell thicknesses by separating the possible factors into hierarchical levels 1) among clutches 2) among egg shells within clutches and 3) among measurements (error). Their findings are similar to Bergs'; the majority of variation is due to the "among clutch" differences (i.e. individual females).

Table 3. One way analysis of variance for average shell thicknesses of eggs from individual female cranes, 1981. *n=3.

Species & Female	df	Mean (mm)	F-Ratio	P-Value
White-naped				
Amazon	6/133	.525	12.44	P<.01
Ise	10/209	.498	16.95	P<.01
Bette*	2/57	.534	0.87	P>.05
Sandhill				
Bert	3/76	.467	27.59	P<.01
Pasque	2/57	.411	9.39	P<.01
Eastern Sarus				
Gloria	6/133	.557	9.26	P<.01
Red-crowned				
Zhurka	13/266	.544	105.41	P<.01
Sauwaka	4/95	.571	48.28	P<.01
Siberian				
Hirakawa	9/190	.514	16.65	P<.01

Table 4. One way analysis of variance for average shell thicknesses between individual female cranes, 1981.

Source of Variations	df	Mean (mm)	F-Ratio	P-Value
9 individual females	8.55	.521	11.17	P<.01

Significant egg shell thickness variations are found between female cranes and within individual female cranes (*Tables 3,4*).

Average shell thicknesses do not vary significantly ($P > 0.05$) within two groups of species:
1) Eastern Sarus and Red-crowned Cranes 2)White-naped and Siberian Cranes, while the thicknesses do vary significantly between the two groups (*Table 5*). The Florida Sandhill Crane, a North American species, varies significantly from all other species. This variation could be related to some global differences between North American species and European species. Anderson and Hickey (1970) found evidence of significant variations in egg shell thicknesses, over broad geographic areas, for several species of pelicans.

Orthogonal contrasts are set up to weigh the different levels of variations and determine how much each level contributes to the variability. The levels of variation are as follows: 1) species 2) individual females 3) individual eggs (error). The first orthogonal contrasts used sixty four treatments (64 individual eggs), with the raw data being twenty individual measurements from each egg. The data was biased when I used the 20 individual measurements as the basis of the mean square error value for all comparisons, and did not provide a valid weighing of the data. Therefore, I found it necessary to set up another group of orthogonal contrasts, this time using the nine treatments (nine individual females), with the raw data being the mean thickness from each egg. It is also necessary to use different mean square denominators when calculating the various F-values (*Table 6*). This set up provides the appropriate balance needed to make the proper evaluations. The dominant

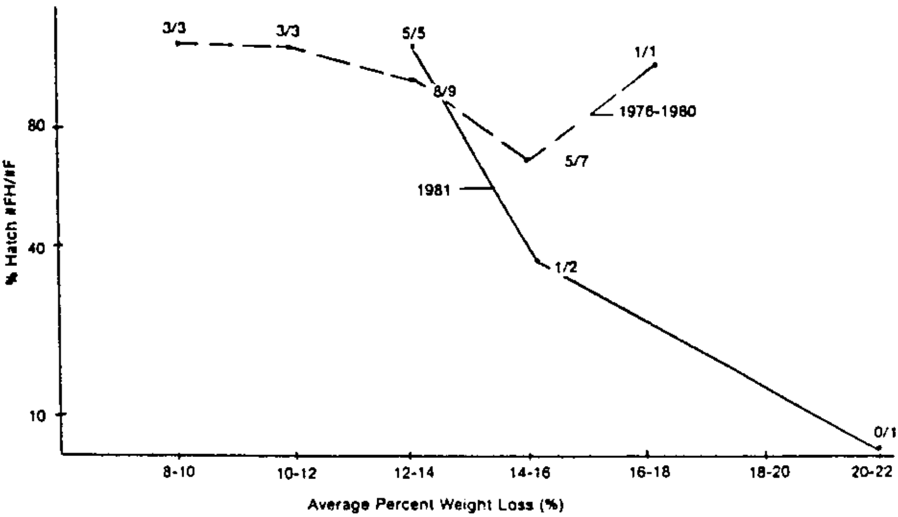

Fig. 3. Correlation between percent hatchability and average percent weight loss for Red-crowned eggs, 1976-1980 and 1981.

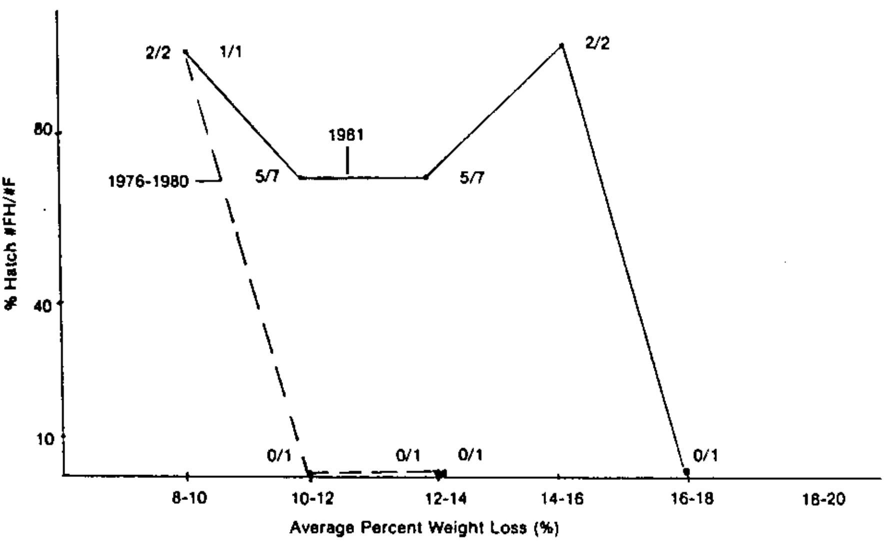

Fig. 4. Correlation between percent hatchability and average percent weight loss for White-naped eggs, 1976-1980 and 1981.

Table 5. One way analysis of variance between average egg shell thickness of White-naped, Eastern Sarus, Red-crowned, Siberian and Sandhill Cranes, 1981.

Species	Mean (mm)	P-alue	Species	Mean (mm)	P-Value
1 Eastern Sarus	.557	P>.05	3 White-naped	.512	P>.05
2 Red-crowned	.552		4 Siberian	.514	
5 Sandhill Florida	.443				
		5 v.s. 1 P .01			
		5 v.s. 2 P .01			
		5 v.s. 3 P .01			
		5 v.s. 4 P .01			

Table 6. Orthogonal contrasts between species, individual females and individual eggs, 1981.

Source of variation	SS	df	MS
Species	705.78	4	176.45
Individual Female	128.05	4	32.01
Individual egg	513.15	55	9.33

$$\frac{\text{species ms}}{\text{Indi. ms}} = \frac{176.45}{32.01} = F{=}5.51 \text{ df}{=}4/4 \; P<.025$$

$$\frac{\text{Indi. ms}}{\text{Indi. egg ms}} = \frac{32.01}{9.33} = F{=}3.43 \text{ df}{=}4/55 \; P<.05$$

contributing factor in crane egg shell thickness variability is the individual female crane (*Table 6*), while the other factors make a significant but smaller contribution.

As mentioned before, fertile egg shells become thinner as incubation progresses (Simkiss 1961, Rothstein 1972). Kreitzer (1972) determined that unincubated eggs have thicker shells than incubated eggs. The shells measured in this study represent different states of fertility (FH, FD I) and different stages of incubation. Despite these facts, there is not a significant difference (P> 0.05) between fertile and infertile shells. This is probably due to small sample sizes.

Section 3

Definite relationships between shell thickness and order in which eggs are deposited have been determined (Berg 1945, Capen 1977 and Rothstein 1972). Rothstein (1972) examined Cedar Waxwing eggs and found their shell thicknesses decreased with each successive egg that was laid, while the last egg was usually as thick as the first egg. Berg (1945) looked at poultry and found the second egg of a two egg clutch tended to be thicker than the first egg. I did not find any of these relationships when I looked at the crane data by clutches. However, when graphs of all the eggs produced in one season by an individual female (8-11 eggs per female) are made, an inverse correlation is evident: eggs become thinner as successive eggs are laid (*Table 7, Fig. 8*). It is important to note that hatchability is not altered by this decrease in shell thickness.

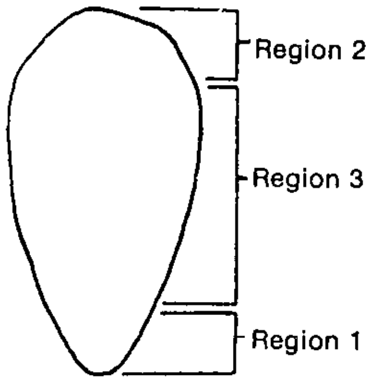

Fig. 5. Measurement regions for egg shell thickness study, 1981.

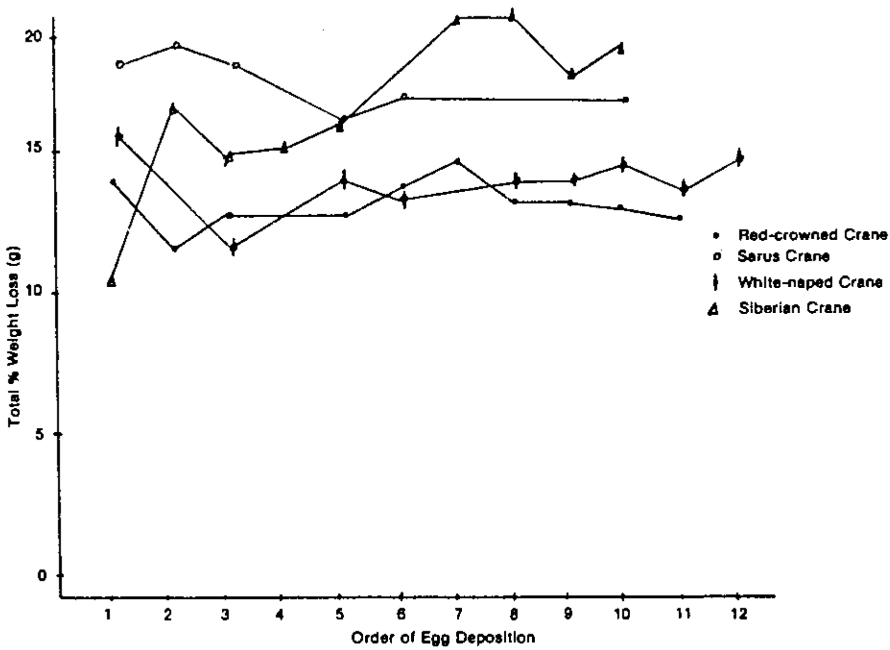

Fig. 6. Total percent weight loss v.s. order of egg deposition for crane eggs, 1981.

An egg shells' morphology affects the amount of water lost during incubation (Rahn et al. 1979). *Table 8* and *Fig. 7* looks at the possible linear relationships between total percent weight loss and average shell thickness. Due to a small sample size the data only shows a hint of significant correlation. Some general observations provide contradictory data:

1) Sarus Cranes have the thickest shells (.5565mm), yet they also have the highest total percent weight loss (17.2%) 2) Sauwaka, a Red-crowned female, has the thickest egg shells (.57mm) and the highest total percent weight loss values (Rogers 1981). Unlike shell thickness, the total percent weight loss is not related to the succession order (*Fig. 6*).

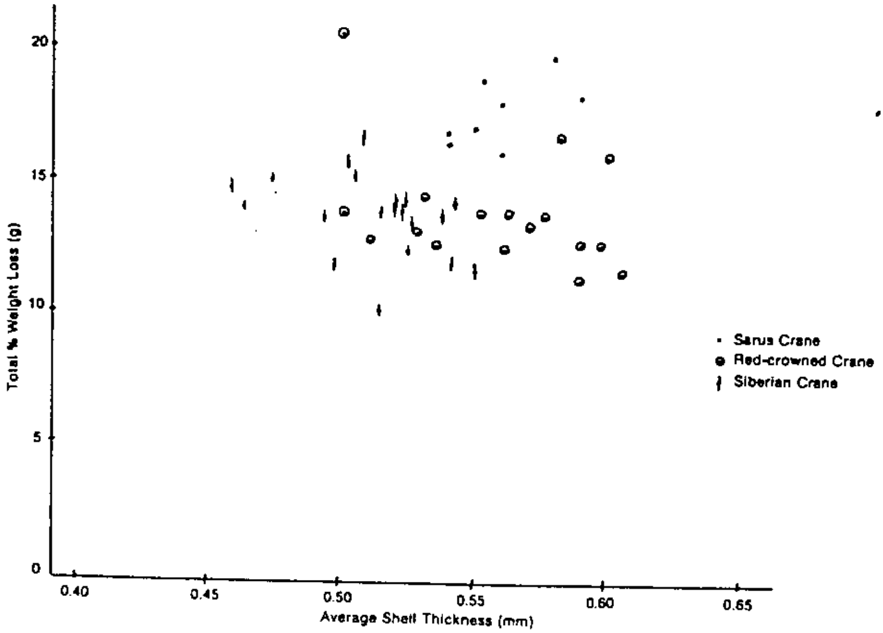

Fig. 7. Total percent weight loss vs. average shell thickness for crane eggs, 1981.

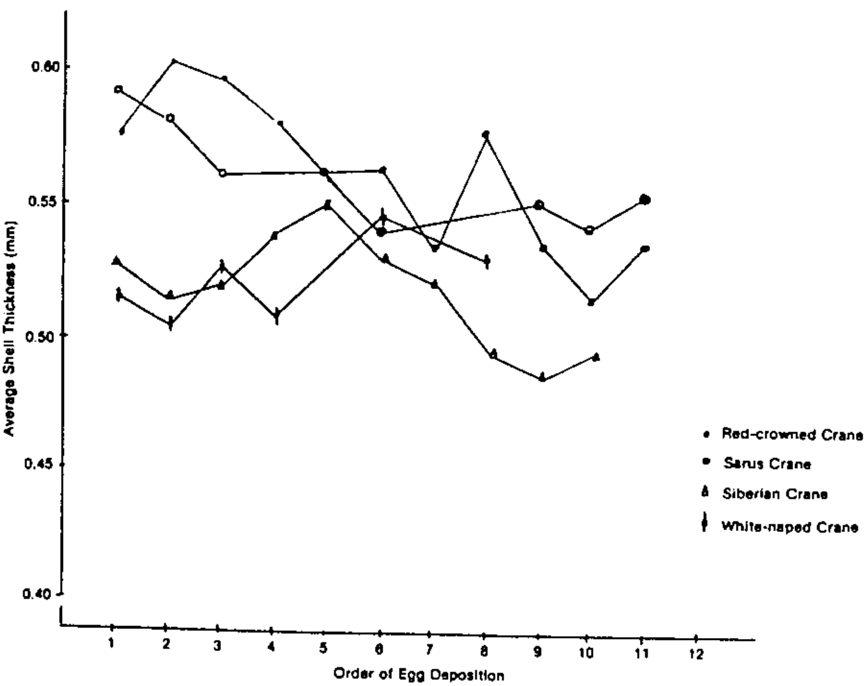

Fig. 8. Average egg shell thickness vs. order of egg deposition for crane eggs, 1981.

Table 7. Linear regression: order of egg deposition vs. average egg shell thicknesses.

Species Individual	n	df	Corr. Coeff.	P-Value
Red-crowned Zhurka	13	11	-0.8415	P<.01
Eastern Sarus Gloria	8	6	-0.8382	P<.01
Siberian Hirakawa	10	8	-0.9989	P<.01
White-naped Amazon	7	6	0.6972	P>.05

Table 8. Linear regression: Total percent weight loss vs. average egg shell thicknesses.

Species	n	df	Corr. Coeff.	P-Value
Red-crowned	18	16	-.45405	P>.05
Eastern Sarus	8	6	.6277	P>.05
Siberian	9	7	-.4814	P>.05
White-naped	21	19	-.3082	P>.05

SUMMARY

1) Red-crowned, White-naped and Siberian Crane eggs, at the ICF, loose 12-16% of their initial weight, during artificial incubation, while Eastern Sarus Crane eggs loose 17.3% of their initial weight.

2) No strong correlations were found between an eggs' initial weight and its percent weight loss.

3) The total percent weight loss of a crane egg does not appear to be related to shell thickness or order in which eggs are deposited.

4) 55 percent of the egg shells were significantly thicker in their middle regions.

5) The dominant contributing factor in a cranes' egg shell thickness variability is the individual female crane.

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