EXPANDED SANDHILL CRANE HUNTING IN THE DAKOTAS AND OKLAHOMA THREATENS ENDANGERED WHOOPING CRANES

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Abstract: Whooping cranes (Grus americana) and sandhill cranes (G. canadensis) migrate through the central United States and Canada each spring and fall. Since the fall of 1982 sandhill crane hunting seasons have been expanded in North Dakota, South Dakota, and Oklahoma, overlapping with the principal migration period of whooping cranes through these states. Whooping crane sightings reported to the United States Fish and Wildlife Service in the Dakotas and Oklahoma in 1983 and 1984 are listed and analyzed. Several whooping cranes were sighted in areas open to sandhill crane hunting in each state. Because whooping cranes resemble sandhills, use the same roosting and feeding areas, and sometimes flock together with sandhill cranes, they may be shot by mistake by hunters. Additional problems arise because sandhill crane hunting is permitted one-half hour before sunrise when only silhouettes are discernable. Fog, rain, or very cloudy weather also provide poor lighting, and cranes positioned between a hunter and the sun cannot be distinguished to species. Recommendations to protect whooping cranes during fall migrations include restricting sandhill crane hunting seasons to the period preceding 18 September in North Dakota, 1 October in South Dakota, and after 20 November in Oklahoma as practiced before 1982. These season changes would limit sandhill hunting to periods preceding or following whooping crane migration.

PROCEEDINGS 1985 CRANE WORKSHOP

Whooping cranes are one of the rarest North American birds, numbering only 86 individuals in 1984-85 in the wild breeding flock that migrates biannually through the Central Flyway. The whooping crane is officially listed as an endangered species and is protected by the Endangered Species Act of 1973. This report presents information about expanded sandhill crane hunting seasons in North Dakota, South Dakota, and Oklahoma and identifies hunting-related dangers threatening whooping cranes during fall migrations through these states. This topic was previously studied by Buller (1967) and Archibald, et al. (1976).

I thank Wallace Jobman and Maurice Anderson at the U.S. Fish and Wildlife Service's Endangered Species Office in Pierre, South Dakota for providing information collected on whooping crane migration sightings. I also thank George Archibald, International Crane Foundation; David Blankinship, National Audubon Society; Roderick Drewien, University of Idaho-Idaho Wildlife Research Institute; Craig Faanes, U.S. Fish and Wildlife Service-Patuxent Wildlife Research Center; Michael Johnson and Charles Schroeder, North Dakota Game and Fish Department; Ernie Kuyt, Canadian Wildlife Service; and Harvey Miller, U.S. Fish and Wildlife Service-Migratory Bird Management Office; for discussions or correspondance valuable in the preparation of this paper.

RESULTS AND DISCUSSION

Confirmed and probable whooping crane sightings reported during fall migration from 1977 through 1984 in the Dakotas and Oklahoma were analzsed to ascertain the migration period when whooping cranes pass through each state. Whooping crane sighting reports are placed in three categories by biologists of the U.S. Fish and Wildlife Service. Confirmed Sighting: Observation made by a State or Federal biologist or officer or by other known qualified observer (trained ornithologist or birder with experience in identification of whooping cranes). A photograph may also be used to confirm sightings. Probable Sighting: No confirmation made by State or federal biologist or officer or by other known qualified observer, yet details of the sighting seem to identify the birds as whooping cranes. To be classified as a probable sighting each of the following factors must be met: (1) location of sighting is within normal migration corridor and is an appropriate site for whooping cranes, (2) date of sighting is within period of migration, (3) accurate physical description, (4) number of birds is reasonable, (5) behavior of the birds does not eliminate whooping cranes, and (6) good probability that the observer would provide reliable report. Unconfirmed Sighting: Details of the sighting meet some, but not all of the six factors listed for a probable sighting. The category "Unconfirmed" is not included in this report.

Sixty-three whooping crane sightings were recorded in North Dakota between 5 September and 8 November, including 12 sightings of 30 whooping cranes in September, 50 sightings of 139 whooping cranes in October, and 1 sighting of 6 whooping cranes in November. Seventy-nine percent of all sightings occurred in October and only four sightings were recorded before 18 September in North Dakota. In South Dakota whooping cranes were reported 41 times between 11 September and 13 November. Two sightings of 11 whooping cranes were reported in September, 30 sightings of 78 whooping cranes in october, and 9 sightings of 40 whooping cranes in November. In Oklahoma 30 sightings were recorded between 1 October and 20 November including 21 sightings of 65 whooping cranes in October and 9 sightings of 54 whooping cranes in November. In addition to these sightings other whooping cranes may not have been observed or were not reported to wildlife officials during migration stopovers. The information presented above can be used to predict periods when whooping cranes may be encountered in each state during fall migration.

After decades of protection, the U.S. Fish and Wildlife Service permitted a limited hunting season for sandhill cranes in an area of west Texas and eastern New Mexico in 1961. Since then sandhill crane hunting has been opened in eight additional states. Previously, sandhill crane hunting seasons were scheduled to avoid overlapping whooping crane migration through individual states. In the Central Flyway, sandhill crane hunting seasons either preceded or followed whooping crane migration periods. However, a drastic change in this policy was implemented when the U.S. Fish and Wildlife Service and Central Flyway Technical Committee permitted expanded sandhill crane hunting seasons in North Dakota, South Dakota, and Oklahoma that overlapped with fall migration of whooping cranes through these states. North Dakota was permitted a 58 day sandhill crane hunting season in Zone 1 from 10 September to 6 November in 1983 and from 8 September to 4 November in 1984. In Zone 2 the 1983 season was from 10 to 30 September and from 8 to 28 September in 1984. The two sandhill crane hunting zones in North Dakota roughly encompass the central one-third of the state (Fig. 1). South Dakota's sandhill crane hunting season was open statewide from 1 October to 6 November in 1983 and 29 September to 4 November in 1984. Oklahoma opened sandhill crane hunting in the west half of the state (west of Interstate 35) from 22 October, 1983 to 22 January, 1984 and from 13 October, 1984 to 13 January, 1985.

Confirmed and probable whooping crane sightings reported in 1983 and 1984 in North Dakota, South Dakota, and Oklahoma are listed (Table 1) and mapped (Fig. 1). In North Dakota, 30 whooping cranes were reported in 11 sightings between 6 October and 8 November in 1983, and 29 whooping cranes were reported in 11 sightings between 15 September and 3 November in 1984. More importantly, 8 whooping cranes were reported in 4 separate sightings inside the sandhill crane hunting area during the extended open season in North Dakota in 1983, while 13 whooping cranes were reported in 5 sightings in the open hunting area in 1984. This means over 30% of the entire Wood Buffalo/Aransas population of whooping cranes was reported to make migration stopovers in North Dakota each year, about 1 of every 7 whoo30% of the entire Wood Buffalo/Aransas population of whooping cranes was reported to make migration stopovers in North Dakota each year, about 1 of every 7 whooping cranes was reported inside North Dakota's sandhill crane hunting area during the open season in 1984. In South Dakota, 25 whooping cranes were reported in 6 sightings in 1983 between 11 October and 9 November, and 8 whooping cranes were reported in 3 sightings between 18 and 29 October, 1984. (Table 1). Nine whooping cranes were reported in three sightings inside the open sandhill crane hunting area in 1983, as were all 8 whooping cranes reported in 1984. In Oklahoma, 28 whooping cranes were reported in 7 sightings between 13 October and 10 November, 1983, and 18 whooping cranes were reported in 6 sightings from 1 October to 20 November, 1984. Eleven whooping cranes were reported in 3 sightings in the open sandhill crane hunting area in 1983, as were 10 whooping cranes in 3 sightings in 1984. Twenty two whooping cranes reported in 5 sightings were obser Whooping cranes often associate with sandhill cranes during fall migration and have been observed flying, feeding, and roosting together on numerous occasions (Johnson 1980). This behavior endangers whooping cranes when they enter sandhill crane hunting areas.

Migration behavior of whooping cranes was intensively studied from 1981 to 1983 by U. S. Fish and Wildlife Service and Canadian Wildlife Service personnel by using radio telemetry equipment to follow migrating whooping cranes (unpubl. data). This study verified that whooping cranes make two types of migration stopovers during fall migration: (1) an overnight stop to feed and rest, or (2) an extended stay for two or more days (one juvenile whooping crane spent a minimum of 40 days from 19 September to 28 October, 1982 near Grenora, North Dakota). Information collected shows most migration stopovers in the Dakotas and Oklahoma are overnight stops, making location and protection of migrating whooping cranes almost impossible. The Central Flyway Technical Committee's Management plan for Midcontinent Sandhill Cranes states that sandhill crane hunting may be temporarily suspended if whooping cranes are present. However, only whooping cranes making extended migration stopovers could be protected in this way, leaving other whooping cranes vulnerable to accidental shooting.

Legal shooting hours for sandhill cranes begin one-half hour before sunrise, which in layman's terms translates to as soon as hunters can see silhouettes. Adverse weather including fog, rain, or very cloudy conditions allows only poor visibility for crane hunting. Also a crane positioned between a hunter and the sun during clear or cloudy skies cannot be distinguished to species. These are all factors adding to the possibility of mistaking a whooping crane for a sandhill crane.

Well-meaning hunters do make mistakes while hunting legal game. Each year tundra swans (Olor columbianus) are shot as snow geese (Chen caerulescens) that have black wingtips, are one-third the size of swans, and have pink feet and bill. Likewise juvenile and hen ring-necked pheasants (Phasianus colchicus) are shot during grouse seasons. This list could be enlarged but the point has been make that hunters sometimes make mistakes. With so few whooping cranes in the wild breeding flock we cannot afford mistakes. In fact a whooping crane was shot in 1968 by a Texas hunter who misidentified it as a snow goose. Also a whooping crane that died of lead poisoning in New Mexico in 1984 had three shotgun pellets imbedded in its body, proof that whooping cranes are still being shot by hunters. Sandhill crane hunters should be protected so they do not make mistakes. Although there are no verified records of whooping cranes being killed by sandhill crane hunters, both whooping cranes and sandhill crane hunters have been protected previously because sandhill crane hunting was not permitted during whooping crane migration in the Central Flyway in earlier years.

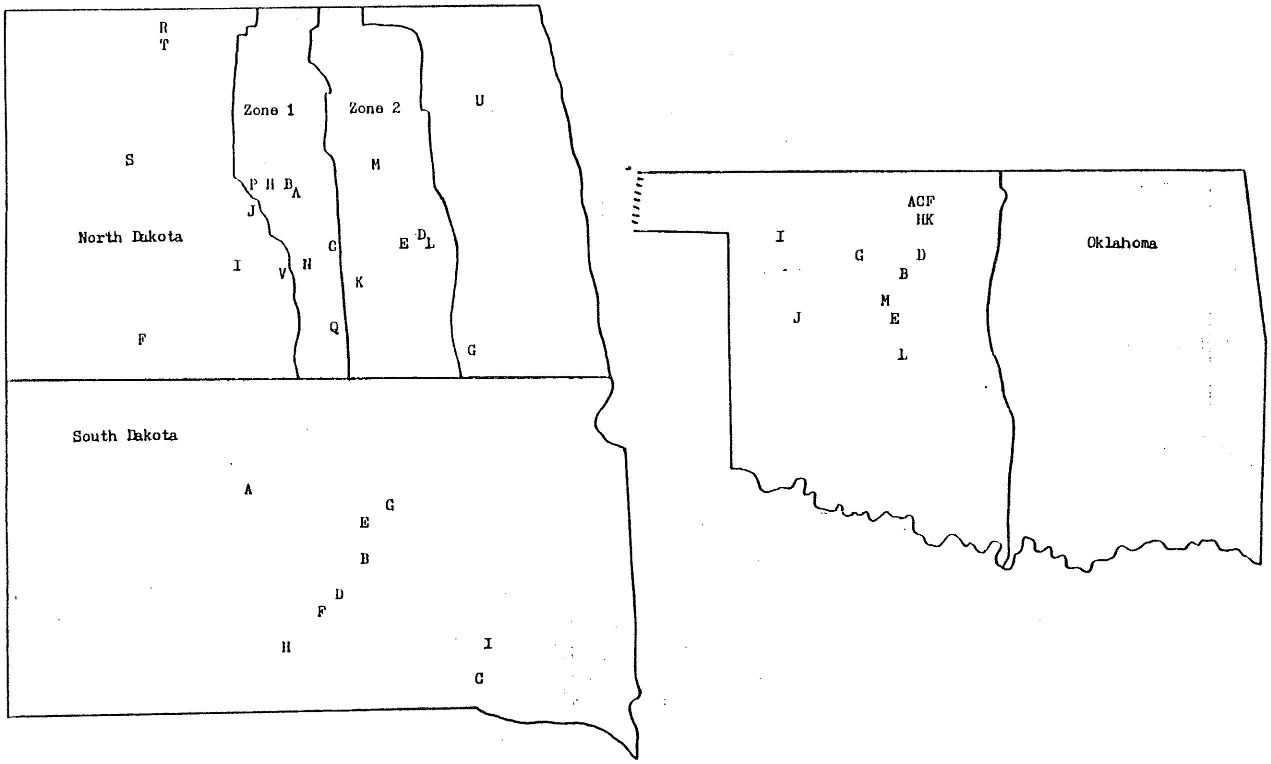

Fig. 1. Whooping crane sighting locations in North Dakota, South Dakota, and Oklahoma in fall 1983 and 1984.

Table 1. Whooping crane sightings in North Dakota, South Dakota, and Oklahoma in fall, 1983 and 1984.

	Date[d]	Whooping cranes	ND hunt zone[a]	Nearest town, county	Sightings status[b]	Location[c]	Cranes in or near hunt zone
North Dakota, 1983							
A	6 O	1	1	Mercer, McLean	P	1	1
B	13 O	1	1	Mercer, McLean	C	1	1
C	15 O	2	1	Lake Andes NWR, Burleigh	P	1	2
D	15 O	1	2	Woodworth, Stutsman	P		
E	18 O	2	2	Pettibone, Kidder	C		
F	18-22 O	6	0	Mott, Hettinger	C		
G	20 O	4	0	Ellendale, Dickey	P		
H	24 O	4	1	Mercer, McLean	P	1	4
I	24-25 O	2	0	New Salem, Morton	C		
J	25 O	2	0	Washburn, Oliver	P	2	(2)[e]
K	7-8 N	5	2	Moffit, Burleigh	C		
Subtotal		30					10
North Dakota, 1984							
L	15 S	4	2	Woodworth, Stutsman	C	1	4
M	18 S	2	2	Harvey, Wells	C	2	2
N	29 S	2	1	McKenzie, Burleigh	C	1	2
P	17 O	2	1	Coleharbor, McLean	P	1	2
Q	19 O to 5 N	3	1	Linton, Emmons	C	1	3
R	20-26 O	3	0	Bowbells, Burke	C		
S	21-27 O	4	0	Newtown, Mountrail	C		
T	25 O	3	0	Bowbells, Burke	P		
U	25 O	1	0	Lawton, Ramsey	P		
V	28 O	2	0	Mandan, Morton	P	2	(2)
Subtotal		26					15
South Dakota, 1983							
A	11-12 O	2		Isabel, Corson	C	1	2
B	25 O	2		Blunt, Hughs	P	1	2
C	26 O	1		Lake Andes, Charles Mix	C	2	(1)
D	26-27 O	5		Ft. Pierre, Stanley	C	1	5
E	8 N	9		Agar, Sulley	P		
F	8-9 N	6		Ft. Pierre, Stanley	C		
Subtotal		25					10
South Dakota, 1984							
G	18 O	2		Gettysburg, Potter	C	1	2
H	26-27 O	4		Stamford, Jackson	C	1	4
I	29 O	2		Plankington, Aurora	C	1	2
Subtotal		8					8

(continued next page)

Table 1 (cont.). Whooping crane sightings in North Dakota, South Dakota, and Oklahoma in fall, 1983 and 1984.

Date[d]	Whooping cranes	ND hunt zone[a]	Nearest town, county	Sightings status[b]	Location[c]	Cranes in or near hunt zone
Oklahoma, 1983						
A 13-22 0	2		Salt Plains NWR, Alfalfa	C		(2)
B 15-16 0	2		Okeene, Blaine-Major	C		
C 15-21 0	3		Salt Plains NWR, Alfalfa	C		
D 22 0	3		Drummond, Garfield	P	1	3
E 29 0	2		Geary, Blaine	C	1	2
F 4 N	10		Salt Plains NWR, Alfalfa	C	2	(10)
G 9-10 N	6		Orion, Major	C	1	6
Subtotal	28					23
Oklahoma, 1984						
H 1 0	2		Salt Plains NWR, Alfalfa	C		
I 24 0	3		Woodward, Woodward	C	1	3
J 24-28 0	1		Washita NWR, Custer	C	2	(1)
K 27-28 0	4		Salt Plains NWR, Alfalfa	C	2	(4)
L 3 N	3		Ft. Cobb, Caddo	C	1	3
M 20 N	4		Watonga, Blaine	P	1	4
Subtotal	18					15

[a] 1 = hunt zone 1, 2 = hunt zone 2, 0 = outside hunt zone

[b] Sighting status as explained in text, C = confirmed, P = Probable.

[c] Location 1 - sighted in open sandhill crane hunting area; 2 - sighted near (i.e.7 km) an open sandhill crane hunting area.

[d] First letters corresponds to sighting locations in Fig. 1, the following numbers are days of the month, and the last letter indicates the month, S = September, 0 = October, N = November.

[e] Numbers in parenthesis indicate sightings on national wildlife refuges in or near crane hunting area.

The areas open to sandhill crane hunting are much larger than necessary in the Dakotas and Oklahoma. Sandhill crane hunting is open statewide in South Dakota, however cranes are not found in every county in South Dakota during fall migration, but are limited to certain fall staging areas. Similarly sandhill cranes are not found in large parts of the open hunting areas in North Dakota and Oklahoma. In the future, sandhill crane hunting should be confined to well defined areas of sandhill crane abundance. This practice will limit areas of potential conflict between whooping cranes and sandhill crane hunters.

Information presented above suggests whooping cranes cannot be adequately protected during fall migration through sandhill crane hunting areas and necessitates limiting sandhill crane hunting to periods preceding or following whooping crane migration through individual states.

RECOMMENDATIONS

Seven recommendations are submitted to the U. S. Fish and Wildlife Service, Central Flyway Technical Committee, and state wildlife departments of North Dakota, South Dakota, and Oklahoma to ensure greater protection for whooping cranes during their fall migration through the central United States:

1) Sandhill crane hunting seasons should be limited to the period preceding 18 September in North Dakota and 1 October in South Dakota, and following 20 November in Oklahoma to avoid overlap with whooping crane migration through these states.

2) The sandhill crane hunting season should be closed immediately when a whooping crane is reported in an open sandhill crane hunting area.

3) Sandhill crane hunting hours should be changed to begin at sunrise or one hour after sunrise to ensure adequate lighting to identify crane species.

4) A list of priorities should be developed to provide federal and state wildlife officials with a logical sequence of tasks to carry out when whooping cranes are sighted in an open sandhill crane hunting area, such as a) close sandhill crane hunting season immediately, b) inform news media and hunters at once, c) conduct aerial and ground observations to monitor whooping crane movements until they leave the sandhill crane hunting area.

5) Education and information materials describing similarities and differences between sandhill cranes and whooping cranes, and the need to protect whooping cranes, should be distributed to sandhill crane hunters along with sandhill crane hunting permits. Hunters should also be informed that sandhill cranes are a trophy quarry with short hunting seasons that begin before whooping crane migration through the Dakotas and after migration through Oklahoma.

6) Sandhill crane hunting areas should be limited to well defined areas of sandhill crane abundance in each state.

7) Closer communication should be developed between the Bismarck, Pierre, Denver, Albuquerque, and Washington D.C. offices of the U. S. Fish and Wildlife Service and appropriate state wildlife departments. An annual briefing including all these offices should precede the opening of sandhill crane hunting seasons. Whooping crane sightings reported during open sandhill crane hunting seasons should be reported to each office and appropriate action taken. The U. S. Fish and Wildlife Service's Endangered Species Office and the Whooping Crane Recovery Team should take a more active role in planning future sandhill crane hunting seasons to ensure the safety of whooping cranes during their fall migration.

Implementation of these recommendations will help to ensure the safety of migrating whooping cranes from accidental hunting mortality. These recommendations will be useful in the Dakotas and Oklahoma as well as eastern Montana, Wyoming, Colorado, New Mexico, and the Canadian provinces of Saskatchewan and Manitoba where additional whooping crane-sandhill crane hunter interactions may occur. This report was prepared to help develop a more positive strategy to protect endangered whooping cranes during their fall migration. I hope that when this information is reviewed the U. S. Fish and Wildlife Service will agree to re-evaluate current regulations governing sandhill crane hunting in North Dakota, South Dakota, and Oklahoma and revise current policy to ensure the safety of migrating whooping cranes.

AUTHOR'S POSTSCRIPT

During the Workshop, participants passed resolution #9 (see Workshop Resolutions, this Proceedings) urging authorities to closely examine any potential risk of extended sandhill crane hunting seasons to whooping cranes. This resolution was sent to the respective state, regional, and federal agencies without effect. In fact, in 1986, North Dakota expanded Zone 1 of the area open to hunting sandhill cranes by 40 percent (Fig. 2), significantly increasing the chances of whooping crane-hunter interactions. In 1985, 11 whooping cranes were observed in three confirmed sightings inside the new area of Zone 1 (sightings E, G, and H in Table 2 and Fig. 3). In 1984, 10 whooping cranes were observed in 3 sightings within the Zone 1 addition (sightings R, S, and T in Table 1 and Fig. 1). No whooping cranes were reported in the Zone 1 addition in 1983.

Whooping crane migration information shows 26% (n=11) of the whooping cranes reported in North Dakota in 1985 stopped in the 1986 Zone 1 addition to the sandhill crane hunting area. Fifty-three percent (n=22) of all whooping cranes reported in North Dakota in 1985 were in areas open to sandhill crane hunting in 1986 or in national wildlife refuges inside the open hunting zones. In 1984, 34 percent (n=10) of the whooping cranes reported were located in the 1986 Zone 1 addition, and 78 percent (n=22) of all whooping cranes reported in North Datkota were located in areas open to sandhill crane hunting in 1986.

This information indicates that whooping cranes are being placed under increasing risk of hunting mortality in North Dakota despite continued whooping crane sightings in opened sandhill crane hunting areas (Table 2, Fig. 3).

Table 2. Whooping crane sightings in North Dakota, South Dakota, and Oklahoma in fall, 1985.

Date[a]			Whooping cranes	Nearest town, county	Sightings status[b]	Number[c] in hunt zone
North Dakota						
A	21	S	2	Steele, Kidder	1-P	2
B	26	S	1	Long Lake NWR, Burleigh	2-C	(2)
C	28	S	4	Long Lake NWR, Burleigh	2-P	(4)
D	1	O	4	Long Lake NWR, Burleigh	2-P	(4)
E	15-17	O	3	Bowbells, Renville	4-C	
F	17	O	4	Bismarck, Burleigh	1-P	4
G	21	O	4	Parshall, Mountrail	4-C	
H	26-27	O	4	Raub, McClean	4-C	
I	26-29	O	3	Mott, Hettinger	4-C	
J	27	O	2	Crosby, Divide	4-P	
K	28	O	7	Pretty Rock NWR, Grant	4-C	
L	8	N	5	Bowman, Bowman	4-P	
Subtotal			41			15
South Dakota						
A	5	O	1	Belle Fourcehe, Butte	1-P	1
B	6	O	4	Leola, McPherson	1-P	4
C	17	O	3	Clark, Clark	1-C	3
D	17	O	2	Miller, Hand	1-P	2
E	26	O	2	Seneca, Faulk	1-C	2
F	26	O	3	Onida, Sully	1-P	3
G	27-29	O	2	Hoven, Edmunds	1-C	2
H	28-29	O	7	Kenel, Corson	1-C	7
I	14	N	2	Parkston, Hutchinson	1-P	2
Subtotals			26			26
Okalahoma						
A	12	O	2	Alva, Woods	3-C	2
B	5	N	3	Salt Plains NWR, Alfalfa	2-C	(3)
Subtotals			5			5

[a] Letters correspond to sighting locations on accompanying map.

[b] Status:
1. Sighted in open hunting area.
2. Sighted near open hunting area.
3. Sighted in hunting area during closed season.
4. Area closed to sandhill crane hunting.

C. confirmed sighting .
P. probable sighting.

[c] Number of whooping cranes observed in open sandhill hunting area. Numbers in parentheses indicate birds sighted on national wildlife refuges located inside the open hunting area.

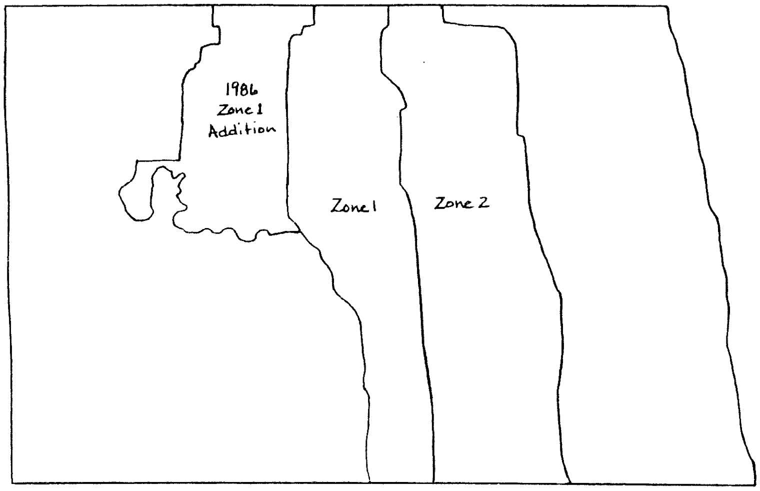

Fig. 2. The 1986 addition to Zone 1 sandhill crane hunting area in North Dakota.

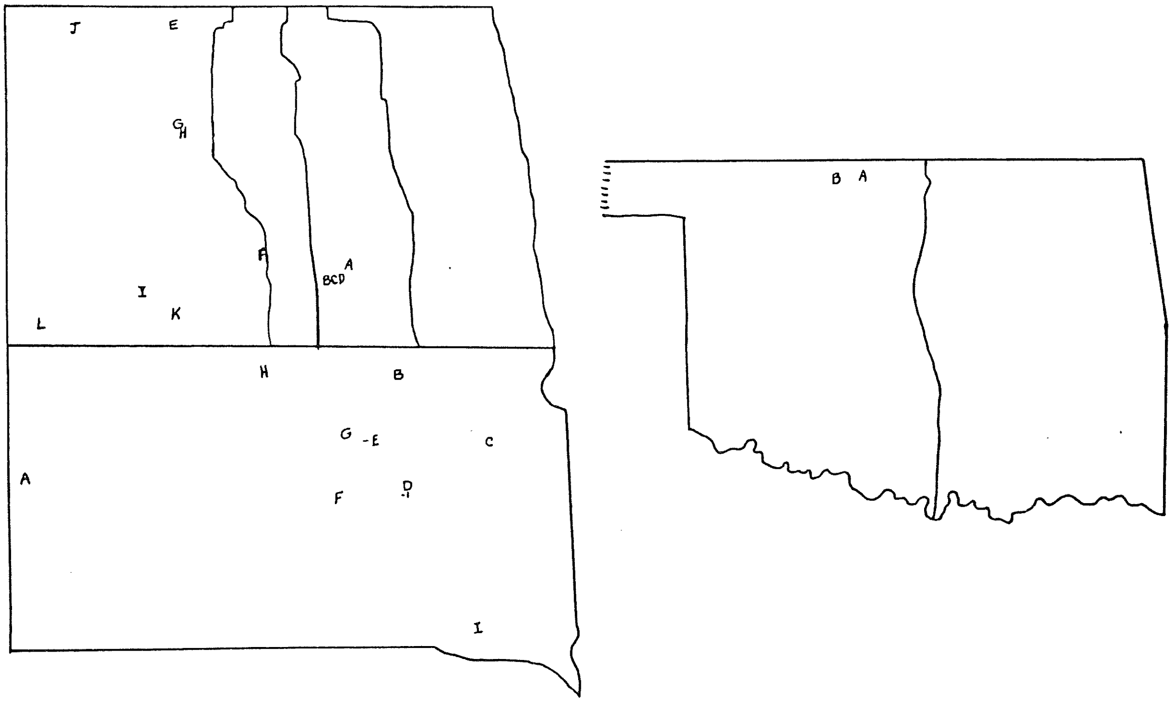

Fig. 3. Whooping crane sighting locations in North Dakota, South Dakota, and Oklahoma in 1985. Letters correspond to sightings listed in Table 2.

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AN EXPERIMENTAL RELEASE OF CAPTIVE-REARED GREATER SANDHILL CRANES

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Abstract: In early summer 1984, 21 captive, parent-reared greater sandhill cranes (*Grus canadensis tabida*) were transported from Patuxent Wildlife Research Center (PWRC) in Laurel, Maryland to Grays Lake National Wildlife Refuge (GLNWR), Idaho and released into the wild after a brief conditioning period in a pen at the release site. Experimental birds included 19 one-year-olds and 2 two-year-olds. Four cranes arrived injured and unable to fly. Cranes were marked with leg bands, collars, and radio transmitters. Behavioral data, including activities in the pen and post-release movements, activity patterns, associations, and social interactions were collected by direct observation and radio telemetry. After 4-6 days in the pen, cranes exhibited a daily activity pattern similar to wild cranes. Activities of post-release birds were similar to those of wild color-marked yearling cranes at Grays Lake except that released birds locomoted more and spent less time in body maintenance. Most released cranes associated with their penmates, and none formed discernible relationships with wild cranes. Eight of 17 cranes capable of flight died during the summer; females had a higher mortality rate. Nine cranes survived to migrate from Grays Lake in October, but only two arrived at wintering grounds in New Mexico. Spring sightings indicated that a minimum of four birds may have survived their first winter and migrated north in the spring. The use of a conditioning pen resulted in minimal dispersion from the release site but it may also have inhibited social integration of the captive-reared birds into wild flocks because penmates formed social groups. Future experiments should consider releasing birds singly to enhance their opportunity to socialize and integrate with wild cranes.

PROCEEDINGS 1985 CRANE WORKSHOP

The release experiment was designed to examine the fitness of captive, parent-reared sandhill cranes to survive in the wild and migrate. The ultimate goal is to develop techniques to release captive-reared whooping cranes (*G. americana*) that can adapt and survive in a migratory wild crane population.

Releases of captive-reared cranes into non-migratory crane populations have been conducted with the Florida and Mississippi sandhill crane subspecies (*G. c. pratensis* and *G. c. pulla*). Release of 18 Florida sandhills, one parent-reared and 17 hand-reared, resulted in long term survival of only the parent-reared bird (Nesbitt 1979). Subsequent crane propagation efforts at Patuxent Wildlife Research Center (PWRC) shifted toward parent-rearing.

Zwank and Derrickson (1981) reported on the release of nine parent-reared Mississippi sandhill cranes after a 6-week conditioning period in a large holding pen at the release site. All were alive 5 months after release.

Research on introduction of captive-reared cranes into migratory populations is scanty. A single parent-reared greater sandhill crane from PWRC released in 1976 at Grays Lake National Wildlife Refuge (GLNWR), Idaho, survived the summer and migrated but was not seen thereafter (Drewien et al. 1981).

In June 1980, 11 parent-reared greater sandhill cranes from PWRC, 4 yearlings and 7 two- and three-year-olds, were liberated without use of a conditioning pen at GLNWR. Seven of 11 birds survived and migrated. One yearling female left the immediate release site and associated with a wild male. She survived and migrated successfully, and was observed on migration and winter areas in subsequent years. The other six survivors migrated from GLNWR as a group and were never seen again (Drewien et al. 1981).

Building on inferences from these past releases, our experiment used greater sandhill cranes, mainly yearlings, hatched and reared by natural or by foster parents at PWRC.

The objectives were: (1) to assess the significance of a brief conditioning period in a pen at the release site in terms of adjustment and survival of the captive-reared cranes, and (2) to compare activities, migration success, and survival rates of released cranes with that of local wild, color-marked cranes of similar age.

Field studies were conducted from June 1984 - April 1985. We wish to thank members of PWRC staff for rearing and shipping the experimental cranes. We especially acknowledge the help of J. Carpenter and S. Derrickson; both provided major assistance in research design and in securing funds for the study. The staff of GLNWR (G. Barney, D. Call, R. Stoor, and C. Peck) provided valuable assistance in various aspects of the project. The study was funded by the U. S. Fish and Wildlife Service through PWRC.

THE STUDY AREA

Grays Lake is an 8,900 ha marsh located in a high altitude (1,950 m) mountain basin in southeastern Idaho. The release site was in the northwestern sector of the refuge (Fig. 1), and was the same area described in a previous release study (Drewien et al. 1981). The site contains optimum summer and fall habitat utilized annually by 250-350 breeding and nonbreeding cranes.

The conditioning pen at the release site was a 7.6 m x 15.25 m pentagon with woven wire sides and a net roof. A small pond within the enclosure provided drinking and roosting facilities. Two troughs contained barley for supplemental feed.

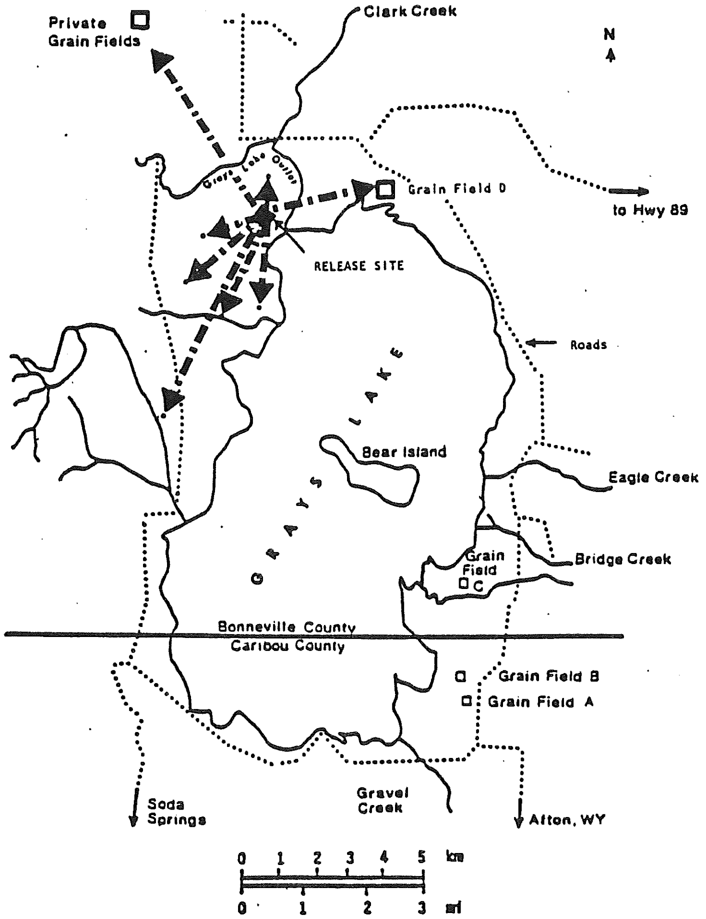

Fig. 1. Summer dispersal (June-August) from the release site for 9 captive-reared that survived to migrate from Grays Lake in October 1984.

METHODS

In June, 1984, 21 parent-reared cranes (19 one-year old and 2 two-years-old) were air-shipped from PWRC, Maryland, to Jackson, Wyoming, then trucked to GLNWR, Idaho. They were shipped about 1 week apart in three groups of 8, 8, and 5 (Table 1).

Upon arrival, cranes were fitted with U. S. Fish and Wildlife Service bands, radio transmitters attached to plastic leg bands (Drewien and Bizeau 1981, Drewien et al. 1981, Melvin et al. 1983), and plastic neck collars, then placed in the conditioning pen. After release, cranes were monitored by radio telemetry and visual sightings. One crane was radio-tracked on 6 October by aircraft on the 1st day of its fall migration from GLNWR.

Table 1. Status of captive-reared greater sandhill cranes from PWRC, Laurel, Maryland, released at Grays Lake NWR, Idaho, June-July, 1984.

				Migration				
		At Grays Lake NWR		From Grays Lake NWR	At San Luis Valley, CO		In Rio Grande Valley, NM	
Group & I. D. No.	Age (yrs) & sex	Arrival	Release from pen	Departure	Arrival	Last Day Observed	1st Day observed	Status
Group IA								
5	1-M	13-June	19-June	19 Oct.				Migrated 19 Oct
6[a]	1-F	"	"	---				Missing 5 Jul[b]
9[a]	1-F	"	"	---				Missing 19 Jul[b]
7	1-F	"	"	---				Missing 5 Jul[b]
Group IB								
2	1-F	14 June	"	---				Found dead 25 Sept
4	1-M	"	"	6 Oct.	20 Oct.	14 Nov.	15 Nov.	Migrated 6 Oct
15	1-F	"	"	---				Missing 30 Jul[b]
11	1-F	"	"	---				Missing 31 Jul[b]
Group II								
18[a]	1-F	21 June	25 June	--				Missing 1 Jul[b]
21	1-M	"	"	7 Oct.				Migrated 7 Oct
22[a]	1-M	"	"	--				Missing 6 Aug[b]
1	2-F	"	"	9 Oct.				Migrated 9 Oct
19	1-F	"	"	--				Missing 26 Jun[b]
20	1-F	"	"	9 Oct.				Migrated 9 Oct
3	2-M	"	"	15 Oct.				Migrated 15 Oct
10	1-F	"	"	--				Killed by eagle 30 Jun
Group III								
23	1-M	27 June	3 July	7 Oct.	20 Oct.	18 Nov.	23 Nov.	Migrated 7 Oct
16	1-M	"	"	7 Oct.				Migrated 7 Oct[c]
13	1-M	"	"	7 Oct.				Migrated 7 Oct
12	1-M	"	"	--				Found dead 26 Jul
14	1-F	"	"	--				Found dead 20 Sept

[a] Unable to fly when received from Patuxent.

[b] Presumed dead.

[c] Observed near Moab, Utah alone on 26 Oct. Not seen thereafter.

The cranes' diurnal activities were monitored by time budget method in the pen and after release. This method consists of recording, at 15-sec intervals, a binomial code corresponding to the observed activity of an individual crane. Major activities recorded included feeding, drinking, alert, resting, comfort movements, locomotion, agonistic behavior, and vocalization (Drewien et al. 1981). Time budget data were compiled on 16 wild yearling sandhill cranes color-marked in 1983 at GLNWR to provide comparisons between activities and survival rates of wild and Patuxent cranes.

We attempted to relocate experimental cranes at their fall migration stop in the San Luis Valley, Colorado, and on principal winter areas in western New Mexico, southeastern Arizona, and northern Mexico by ground and aerial radio searches. When possible, time budget data were collected at migration and winter areas.

RESULTS

The first shipment of eight cranes arrived at Grays Lake with bloody wrist joints that resulted from beating unbrailed wings against their wooden crates while in transit. Some wing damage appeared to be from earlier injuries; the wrist joints of four cranes were so stiff they were incapable of flight. Otherwise, condition of birds on arrival appeared normal.

Behavior in the Conditioning Pen

Interactions. Group I went into the pen as two subgroups on successive days (Table 1). Group IA cranes at first chased, pecked, and generally dominated new arrivals (Group IB), but this behavior subsided in succeeding days.

Activity Phases. Activities in the pen were classified into three phases. The first, *disorientation*, occurred only during the first few hours and resulted from shipping, handling, and unfamiliar surroundings. Drinking, alert behavior, and preening of marking devices characterized this phase (Table 2). Alert behavior included visually inspecting the pen and surrounding area. Preening radio attachments and neck collars constituted two-thirds of comfort movements. Little feeding or vocalization occurred.

Table 2. Activities of captive-reared sandhill cranes while in conditioning pen at Grays Lake NWR, by phase, 13 June - 3 July 1984.

Activity	Phase 1 Disorientation		Phase 2 Adjustment		Phase 3 Boredom		Total	
	n	%	n	%	n	%	n	%
Foraging	82	7.1	1,720	18.9	244	14.8	2,046	17.2
Drinking	27	2.3	46	0.5	8	0.5	81	0.7
Alert	591	50.7	2,587	28.4	369	22.3	3,547	29.7
Resting	77	6.6	1,004	11.0	3	0.2	1,084	9.1
Comfort movements	220	18.9	1,367	15.0	332	20.1	1,919	16.1
Locomotion (other than pacing)	166	14.2	1,477	16.2	251	15.2	1,894	15.9
Agonistic behavior	1	0.1	18	0.2	4	0.2	23	0.2
Vocalization	0	0	4	0	2	0.1	6	0.1
Pacing and pecking at pen	2	0.2	885	9.7	439	26.6	1,326	11.1
Total time budget obs. (n - %)	1,166	100.1	9,108	99.9	1,652	100.0	11,926	100.1
No. hours of observation	4.9		38.0		6.9		49.7	

Adjustment, the second phase, took place during days 2-4 when birds acclimated to the pen and release site. Preening marking devices, drinking, and exploratory behaviors decreased markedly. Foraging, pacing, and resting increased. Activities of penned cranes gradually paralleled that of wild birds. They preened at first light, fed until mid-morning, loafed through the afternoon, then fed again until roosting near sunset.

Boredom, the third phase, became evident from day 5 until release. Cranes exhibited restless behavior--examining and pecking the wire, probing the base of the side walls, and much pacing. Comfort movements increased as cranes again preened collars and radio attachments.

Wild cranes were attracted to penned birds. Penned birds were alert to the approach of free-roaming cranes, but generally ignored them after they were near the pen. Penned birds exhibited interest in vocalizations of wild cranes and intently watched flying cranes.

Dispersal and Movements

Upon release, most birds flew 50-200 m. They moved about singly or in groups of two to five, eventually rejoining other members of their release group before disappearing in the nearby marsh vegetation. Several individuals wandered onto territories of breeding pairs and were attacked and beaten before escaping.

All liberated cranes (except No. 11) left the immediate vicinity of the pen (Fig. 1) within 2 weeks and wandered up to 3 km. Most cranes established a summer use area and a defined activity pattern by the 3rd week after release. All summer areas used by the Patuxent cranes were inhabited by wild cranes.

Nine of 21 cranes survived to migrate. Because movement data for 12 dead or missing cranes were fragmentary, only movements of the 9 survivors are presented here (Fig. 1).

Through July and early August, all but one (Crane 5) of the nine birds remained within 3 km of the release site.

In August, ripening barley attracted both wild and released cranes. By 8 August, crane 5 joined wild cranes on daily feeding flights to private grain fields 5 km north of the release site. By early September, six Patuxent birds had moved to the area near grainfield D (Fig. 1), 4 km from the release site. Three other cranes also moved to this area by early October.

Daily Activity Patterns

Patuxent cranes exhibited the same daily activity patterns as wild cranes throughout the summer and fall. They engaged in comfort activities briefly at sunrise, either at the roost or after moving to a meadow, then fed for several hours. They loafed during mid-day hours; this normally included preening, resting, and some foraging. They fed again from mid-afternoon until sunset and then returned to roost in the marsh.

Daily activities of released and wild cranes varied little over summer and fall, but feeding and loafing habitat use changed with seasonal conditions. In early summer (June), most cranes foraged on natural foods in wet meadows. Loafing occurred at or near the marsh edge where emergent vegetation provided escape cover. In mid-summer (July - mid-August), foraging shifted to dry meadows and adjacent uplands where large numbers of invertebrates, mainly grasshoppers, were abundant. During this period, both wild and Patuxent cranes loafed on high vantage points. By mid-August, most wild cranes began feeding in ripening grainfields. In contrast, only three Patuxent cranes were observed in grain fields before staging for migration (September - October). The daily routine of all cranes during the staging period (September - October) differed from the summer only in that feeding increased over summer levels as birds prepared for migration.

Associations

Patuxent cranes generally remained in close association with others from their release group. Mixing with wild cranes occurred, but released birds usually remained on the periphery of flocks or in their own isolated groups. No discernible, long-term associations were established between Patuxent and wild cranes.

Group I birds stayed together near the release site all summer and were seen in groups containing up to seven of their release cohort. Crane 5 left the group 30 July; on 8 August it was observed flying to grainfields with a wild flock. By mid-September, Crane 5 was again associating with Patuxent birds on grainfield D.

Birds from Group II formed an association consisting of cranes 1, 3, 20, and 18. Cranes 1 and 20 not only associated during the summer but migrated together. Cranes from Group III formed an association made up of nos. 13, 16, 23, and 12.

A total of 48 associations between surviving cranes was recorded during the summer (Table 3). Most were among cranes from the same release group; only 8 inter-group associations were observed.

During the fall staging period, all released cranes frequented grainfield D (Fig. 1) and 26 associations were recorded. Inter-group associations were common during this mixing period (Table 3).

Agonistic Behavior

Patuxent cranes were observed in 117 encounters with wild cranes (Table 4). Most did not involve harmful body contact. Patuxent cranes were rarely seen initiating aggression. Instead, they attempted to avoid encounters by walking with head held low in submissive posture, remaining on the fringes of flocks and quickly retreating when threatened. Attack, submission, and retaliation behaviors were as described by Drewien et al. (1981).

During summer, 45 agonistic interactions between wild and Patuxent cranes were recorded. Wild cranes won 91% of the interactions (Table 4). Twenty-five of 45 encounters occurred immediately after release and involved territorial pairs. Crane 9, shortly after being released, was knocked down and pecked on the head and neck by a territorial male, but suffered no apparent injuries. Immediately after release, crane 19 was knocked down by a territorial male who stood on and pecked her repeatedly. Crane 19 finally escaped but was not seen again alive. Whether or not Crane 19 died of injuries inflicted by the territorial male is unknown.

During the staging period (Sept.-Oct.), 72 agonistic encounters were observed when cranes were concentrated on grainfields. Most encounters were limited to threats or a single peck. Patuxent cranes still remained at edges of flocks and acted submissively. They lost nearly 92% of these encounters (Table 4).

Sixteen marked yearling wild cranes were observed throughout the summer and fall and 112 agonistic interactions with other cranes were recorded (Table 4). Overall, wild yearling cranes won a significantly larger proportion of their encounters with other wild cranes than did the Patuxent cranes (P = <0.05, z test).

Table 3. Associations of surviving Patuxent cranes at Grays Lake during summer (June-August) and staging period (September-October), 1984.

Crane associations (Id. nos.)	Release group	Frequency n	%	Crane Associations (Id. nos.)	Release group	Frequency n	%
Summer				Fall staging			
4, 5	I	15	31.3	13, 16, 21, 23	II, III	13	50.0
1, 3, 20	II	11	23.0	13, 16, 23	III	3	11.5
13, 16, 23	III	5	10.4	1, 3, 20	II	3	11.5
3, 20	II	5	10.4	1, 20	II	3	11.5
13, 16, 21, 23	II, III	3	6.3	1, 4, 20	I, II	1	3.8
13, 16, 21	II, III	2	4.2	1, 5	I, II	1	3.8
5, 21	I, II	2	4.2	4, 21	I, II	1	3.8
1, 3, 16, 20	II	1	2.1	21, 23	II, III	1	3.8
13, 16	III	1	2.1				
13, 23	III	1	2.1				
16, 21	II, III	1	2.1				
Total		48	100.3			26	99.7

Time Budget

Time budget analysis revealed that four categories, i.e., foraging, alert, comfort, and locomotion, constituted > 95% of activities for both released and wild cranes (Table 5). Although time spent in foraging and alert activities was similar for released and wild birds, released cranes spent significantly less time in comfort behavior (P = ≤0.05, z test). The proportion of time spent in all other activities was similar.

Mortality

Of 21 cranes released, 12 died or disappeared before October. Four birds, unable to fly because of wing impairment, were excluded from mortality calculations. The four flightless

Table 4. Results of agonistic interactions between Patuxent and wild cranes and between wild color-marked yearling cranes and other wild cranes, Grays Lake NWR, June-October 1984.

	Patuxent vs. wild		Wild marked yearlings vs. Other wild yearlings	
	n	lose %	n	lose %
Summer (June-Aug.)	45	91.1	18	72.2
Fall staging (Sept.-Oct.)	72	91.7	94	83.0
Total/mean %	117	91.5	112	81.3

Table 5. Comparison of time budget activities for Patuxent cranes and wild color-marked yearling cranes at Grays Lake NWR, Idaho (June-October 1984) and San Luis Valley, Colorado (November 1984).

Activity	Grays Lake NWR				San Luis Valley			
	Patuxent		Wild		Patuxent		Wild	
	n	%	n	%	n	%	n	%
Foraging	5,899	29.5	6,205	35.6	2,126	57.4	2,219	61.1
Drinking	22	0.1	15	0.1	4	0.1	4	0.1
Alert	3,074	15.4	3,369	19.4	455	12.3	443	12.2
Resting	217	1.1	185	1.1	22	0.6	0	0
Comfort movements	1,175	5.9	2,387	13.7	141	3.8	176	4.8
Locomotion	8,949	44.7	4,776	27.4	876	23.6	765	21.0
Agonistic behavior	28	0.1	76	0.4	9	0.2	6	0.2
Vocalization	25	0.1	40	0.2	0	0	1	tr.
Out of sight	610	3.1	355	2.0	74	2.0	19	0.5
Total (n, %)	19,999	100.0	17,408	99.9	3,707[a]	100.0	3,633	99.9
Hours of observation	83.3		72.5		15.4		15.1	

[a] Based on time budgets of the only 2 Patuxent cranes that successfully migrated to the San Luis Valley migration stopping point.

birds died or disappeared within 7 weeks after release (19 June - 6 August). Of 17 cranes capable of flight, 6 died or disappeared during the first 6 weeks after release and 2 others succumbed later (Table 1). All documented mortalities and/or last observations of missing birds were within 2.5 km of the release site.

Mortality was higher for females; of 17 birds capable of flight, 7 of 9 females died but only 1 of 8 males. Time budget analysis failed to provide insight into reasons for the higher female mortality rate. Time budget data also failed to demonstrate any notable behavioral differences between survivors and nonsurvivors for the 6 week period 19 June - 31 July, the period when 75% of mortality occurred.

Predation, primarily by golden eagles (Aquila chrysaetos), was suspected as a major cause of mortality. Several eagles hunted regularly in the vicinity of the release area. On 30 June, we watched an eagle kill crane 10 on an open hillside 2 km south of the release site. This crane was standing within 30 m of 20-30 other cranes when the eagle struck her at the base of the neck. Death was almost instantaneous. When the carcass was inspected 20 minutes later, the eagle had consumed some of the breast.

Migration

In late August, wild cranes started gathering at two major staging areas: (1) near grainfields A, B, and C and (2) at grainfield D (Fig. 1). All surviving Patuxent cranes moved to grainfield D, although four birds (cranes 1, 3, 5, and 20) subsequently moved to the area near grainfield C before migrating.

Crane 4, the first Patuxent bird to migrate, was radio-tracked by aircraft during its 1st day of migration. It departed on 6 October at 1220 hours with 20 wild birds. After departing, his group joined a flock of some 100 cranes. The flock migrated across southwestern Wyoming, passing 29 km east of Ft. Bridger at 1702 hours. During this portion of the migration the flock reached a maximum altitude of 3,505 m at 1642 hours.

At 1800 hours, the flock crossed the Uinta Mountains in northeastern Utah flying at 3,718 m. The flock descended into the Green River Valley and landed in a wetland 3 km south of Jensen, Uinta County, Utah at 1914 hours. Crane 4 had flown 351 km southeast from Grays Lake in 6.9 hours at an average ground speed of 50.9 kmph. The migration route traveled was similar to that followed by a whooping crane and sandhill cranes previously radio-tracked from Grays Lake (Drewien and Bizeau 1981).

Four birds (13, 16, 21, and 23) migrated together with wild cranes on 7 October in the same flock. Cranes 1 and 20 departed together and were not with wild migrants. Cranes 3, 4, and 5 each left Grays Lake in separate wild flocks (Table 1).

Of nine cranes that migrated, only cranes 4 and 23 were relocated in the San Luis Valley, Colorado, the traditional migration stop for cranes of the Rocky Mountain population (Drewien and Bizeau 1974). Both birds were located on 20 October in grainfields adjacent to the Rio Grande River northeast of Monte Vista National Wildlife Refuge. Intensive ground radio searches were conducted throughout the Valley, but no other Patuxent cranes were found.

Only one other fall observation on migrating Patuxent cranes was received. On 26 October, crane 16 was observed alone in a corn field near Moab, Utah, by B. de Gruyter, biologist, Bureau of Land Management, U. S. Department of Interior. This location is about 100 km southwest of the normal migration route for cranes from Grays Lake.

The two Patuxent cranes that arrived in the San Luis Valley utilized wetlands and meadows along the Rio Grande River, fed in nearby grainfields, and followed daily activity patterns of wild birds they accompanied. These two cranes encountered each other at least twice in the Valley but did not remain together. Neither exhibited any discernible close associations with individual wild birds. Time budget data collected on the two cranes in the Valley indicated that their activities were very similar to those of wild yearling sandhill cranes (Table 5).

Two cranes remained in the Valley until mid-November. At 1027 hours on 14 November, crane 4 migrated south with wild cranes. Crane 23 initiated migration on 14 November, but returned; it was last observed in the Valley on 18 November.

Most cranes of the Rocky Mountain population winter along the middle Rio Grande River in New Mexico at or near the Bosque del Apache National Wildlife Refuge (Bosque NWR) (Drewien and Bizeau 1974). On 15 November, Crane 4 was located at Bernardo State Waterfowl Management Area (SWMA), 64 km north of Bosque NWR. Crane 23 was found in the same location on 23 November.

Crane 4 was last observed on 27 November about 7 km south of Bernardo SWMA standing alone on the Rio Grande River. Crane 23 was relocated on 13 December in the Hatch Valley near Caballo

Reservoir and it remained in this area for the winter. On 25-27 February it stopped at the Belen SWMA during the spring migration. Crane 23 was relocated in the San Luis Valley, Colorado, during spring migration on 7-10 April (Fig. 2).

Extensive radio searches by aircraft of winter areas in western New Mexico and southeastern Arizona on 27 November 1984 and 10 February 1985 failed to locate any additional Patuxent cranes. A ground radio survey of selected crane winter locales in nearby Chihuahua, Mexico, also failed to locate any Patuxent cranes. Thus, only 2 of 9 migrating Patuxent cranes were observed on winter areas while 9 of 16 wild color-marked yearling cranes used as controls were seen during migration in Colorado or on wintering areas in New Mexico. No wild color-marked cranes were radio-tagged, nor did we make a concerted effort to locate them. Consequently, our resightings represent a minimum value for the survival of marked yearlings utilized as controls.

One, Crane 5, migrated from Grays Lake on 19 October but was not relocated at migration stops or winter areas traditionally utilized by wild cranes from Grays Lake. However, it survived in an unknown winter site and reappeared on 9-10 April 1985 near Farson, Wyoming (Fig. 2) where it was identified by Wyoming Game and Fish Department (WGFD) personnel (D. Lockman and M. Rowland, pers. comm.). It was traveling with wild sandhills returning to summer areas.

On 21 April 1985, two marked sandhills fitting the markings of Patuxent cranes were observed together at the south end of Ocean Lake near Riverton, Wyoming by WGFD Game Warden T. Britt (D. Lockman, pers. comm.). If this sighting is correct then a minimum of four out of nine southbound Patuxent sandhills may have survived their first winter and migrated north in the spring.

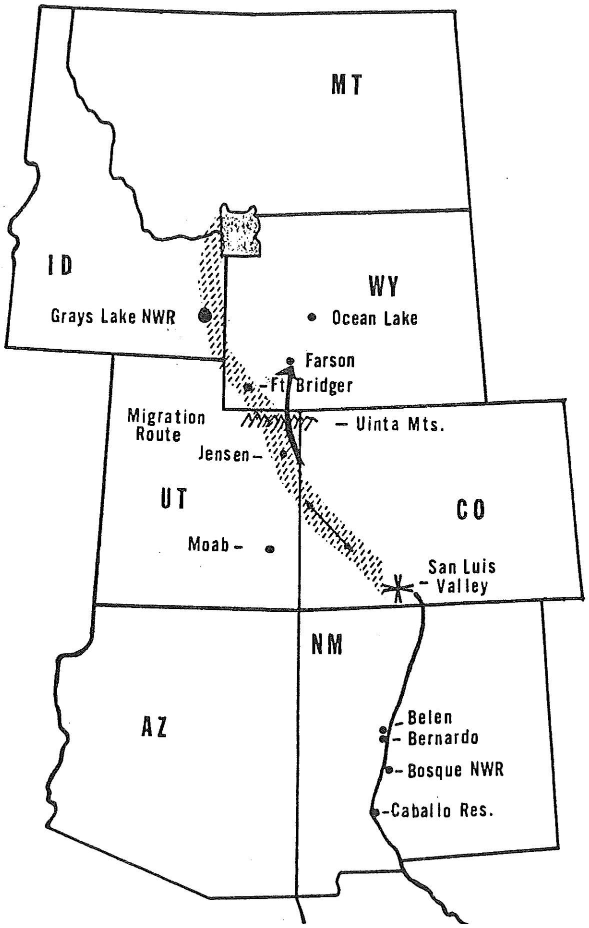

Fig. 2. Sightings during fall, winter, and spring 1984-85 of captive-reared sandhill cranes released at Grays Lake NWR, Idaho in June 1984. Migration route is adapted from Drewien and Bizeau (1974, 1981).

DISCUSSION AND CONCLUSIONS

The conditioning period in the pen provided cranes an opportunity to adjust to their new surroundings after the transfer from Patuxent. Time budget data on penned birds indicate that the conditioning period of less than 1 week was adequate because a daily routine was quickly established and birds displayed boredom behavior before release.

Post-release time budget comparisons revealed that summer activity patterns of released and wild cranes were similar except that released birds spent significantly more time in locomotion and less time in comfort behaviors than did wild birds. This discrepancy is probably related to two factors: (1) released birds were less efficient at fulfilling their daily requirements, thus they moved about more and spent less time in loafing and comfort activities, and (2) released birds were the lowest members of the social hierarchy, forcing them to move about frequently to avoid agonistic interactions with wild cranes. Patuxent sandhills from the previous release experiment at Grays Lake also exhibited a high proportion of locomotion activity compared to wild sandhills (Drewien et al. 1981).

Comparison with the direct release at GLNWR in 1980 (Drewien et al. 1981) shows that there was less dispersal of cranes held in the pen. This, however, did not translate into better summer survival for the pen-release cranes.

Confinement probably contributed to the formation of the intragroup associations that persisted after release. These associations probably inhibited social integration with wild birds. However, summer-long associations of Patuxent birds also occurred in the 1980 release where no pen was used. Such close ties between captive-reared birds were probably unavoidably formed during the rearing period at Patuxent.

Comparisons between released and marked wild yearlings showed that wild yearlings were much more successful in agonistic encounters with other wild cranes. The generally submissive behavior of Patuxent cranes may have made them more vulnerable to summer predation by keeping them on the edges of feeding flocks or in isolated groups and may have similarly affected their survival during migration.

Survival of the wild marked yearlings during the summer and in migration was higher than released cranes. The higher success of the wild yearlings in completing migration is probably due to their better social integraton into migrating flocks and the fact that they already completed the migration as juveniles.

As in the 1980 release, most mortality in 1984 occurred during the first 6 weeks following release. Overall, summer survival rates were similar (64% in 1980 vs. 53% in 1984).

Eagle predation was believed to be the primary cause of mortality in this study, but was not a hazard in 1980. To avoid eagle attacks, released cranes had to learn the "bunching" behavior exhibited by wild cranes. When an eagle is sighted, wild cranes form tight groups, thus making it difficult for the eagle to select an individual target. During the learning period, the captive-reared cranes, especially single birds, present attractive targets for eagles. Lack of integration into wild flocks may result in slower learning of "bunching" behavior and thus higher mortality of captive-reared birds.

Of 17 flying cranes released (9 females and 8 males), only nine survived the summer (2 females and 7 males). Both successful migrants seen on the winter grounds were males. This indicates that captive-reared females may have lower survival rates. Although our observations suggest that captive-reared females were generally more submissive with wild cranes than were males, we detected no difference in activity patterns between the sexes that would make females more casualty-prone.

Compared to the 1980 study, where one out of seven migrants reached the winter area, the 1984 release was only slightly more successful (2 of 9). In the 1980 study, the lone successful migrant (a yearling female), developed a close association with a wild male that probably enhanced her survival chances. Neither of the two successful migrants in 1984, both yearling males, developed permanent associations with wild cranes before or during migration.

The high mortality of released cranes during migration was predictable if we accept the premise that released cranes must socially integrate into wild flocks before migration. They did not achieve any measurable degree of social integration while at Grays Lake. They were still associating mainly with their cohorts.

RECOMMENDATION

Two group-release experiments have been completed and both yielded poor survival through migration. We suggest that in future attempts to release captive-reared cranes into a migratory situation, birds be placed in individual conditioning pens and released singly to facilitate integration into wild flocks. To discourage regrouping with Patuxent associates, birds should be spaced 2 km or farther apart and released birds should be unpaired, and both sexes equally represented to further test differential mortality. Another alternative would be to capture unpaired wild sandhills and place one in a conditioning pen with each captive-reared sandhill. This might facilitate formation of a social bond, and the wild bird could then serve as a "guide" when both sandhills are released into the wild.

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WINTER AND SPRING DISTRIBUTION OF GREATER SANDHILL CRANES FROM SOUTHCENTRAL IDAHO

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Abstract: Forty-three greater sandhill cranes (Grus canadensis tabida) were banded and color-marked at five locations in southcentral Idaho during 1971-1974. Between 1973-1984, 14 reports of 13 marked cranes were obtained during migration in Colorado and New Mexico and at wintering grounds near the Mexican border in New Mexico (Columbus), southeastern Arizona (Willcox Playa), and in northwestern Chihuahua, Mexico. Cranes breeding in southcentral Idaho are affiliated with the Rocky Mountain population but most individuals appear to winter south and west of the principal winter range in the Rio Grande Valley of New Mexico. The primary fall and spring migration route of the southcentral Idaho subpopulation remains unknown.

PROCEEDINGS 1985 CRANE WORKSHOP

Three breeding populations of greater sandhill cranes have been recently identified in the western United States: the Rocky Mountain, Central Valley, and Colorado River Valley populations (Littlefield and Ryder 1968, Drewien and Bizeau 1974, Braun et al. 1975, Drewien et al. 1976, Lewis 1977, Littlefield and Thompson 1979). The Rocky Mountain population summers principally in southeastern Idaho, western Wyoming, and southwestern Montana. The primary winter area is in the middle Rio Grande Valley, New Mexico, although some cranes winter in southwestern New Mexico, southeastern Arizona, and northern Mexico (Drewien and Bizeau 1974, Lewis 1977). Major breeding areas for the Central Valley population are in southeastern Oregon and northeastern California. This population winters in the Central Valley of California (Lewis 1977, Littlefield and Thompson 1979).

Several small breeding groups of sandhill cranes are dispersed in northeastern Nevada and southcentral Idaho between the major, disjunct Rocky Mountain and Central Valley populations. A wintering area supporting 800-1000 greater sandhill cranes along the Colorado River near Poston, Arizona, was under observation by C. D. Littlefield from 1969-1972 (pers. comm.). During the early 1970's, we postulated that these cranes might constitute a third breeding population.

Between 1971-74, we color-marked 49 cranes on nesting areas in southcentral Idaho and northeastern Nevada to test the hypothesis that these cranes were among those wintering on the Colorado River. Only cranes from Nevada were observed on the Colorado River wintering grounds (Drewien et al. 1976). Since only 12.2% of the total cranes marked were from Nevada, we speculated that cranes from southcentral Idaho were wintering in unknown locations in southwestern United States and Mexico.

This paper summarizes reports on migration and winter sightings of cranes banded in southcentral Idaho. Our studies were funded by the U. S. Fish and Wildlife Service, Rob and Bessie Welder Wildlife Foundation, and the National Audubon Society. We thank W. Brown for reviewing the manuscript.

METHODS

Flightless young cranes were captured, banded, and color-marked on five summer areas in Blaine, Camas, and Custer counties, Idaho, during 1971-1974 (Fig. 1). Cranes were captured by pursuing them on foot or in a vehicle. Cranes were individually marked with aluminum neck collars which were 8.9 cm high and color-coded with Scotch-Brand plastic film tape. A colored 3.8 x 7.6 cm. leg tag was placed on one leg above the tibio-tarsal joint (Drewien and Bizeau 1974).

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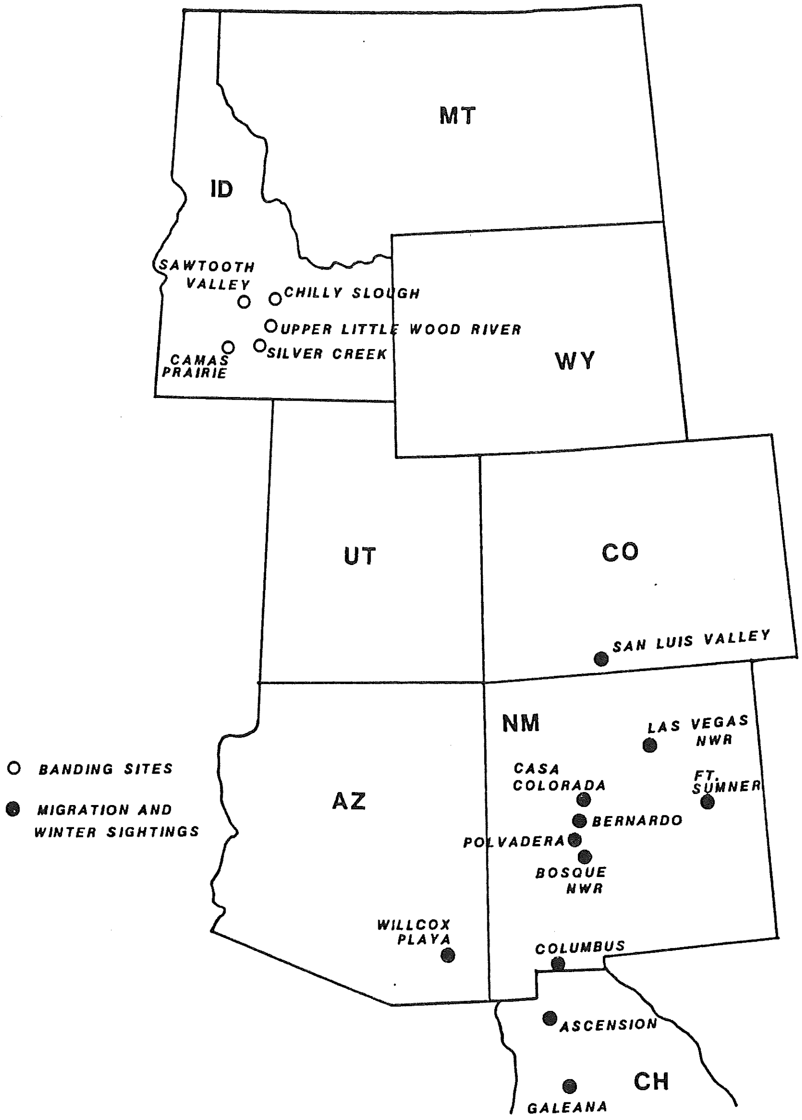

Fig. 1. Migration and winter area sightings of greater sandhill cranes banded on summer areas in southcentral Idaho.

The Colorado River wintering grounds were surveyed for marked cranes in January 1973 and 1974. Wintering areas in the middle Rio Grande Valley, primarily between Los Lunas and Bosque del Apache National Wildlife Refuge, New Mexico, have been intensively surveyed annually since 1971. We have surveyed other sites in southwestern New Mexico and southeastern Arizona once or twice each winter since 1971. We conducted limited ground surveys in some crane wintering areas in northern Mexico in 1972 and 1979-1984.

RESULTS

Forty-three flightless young were banded and color-marked during 1971-1974 in southcentral Idaho (Table 1, Fig. 1). Color-marking had no apparent detrimental effect as chicks rejoined their parents soon after being released. Several smaller chicks lost their collars. When possible, these young were recaptured when larger in size and refitted with new collars.

Fourteen locations were obtained on 13 marked cranes between 1973-1984 (Table 1). Of 14 reports received, 9 were at winter sites and 4 were during spring migration. One other record from the Rio Grande Valley, New Mexico, could be either a fall migrant or winter sighting because some cranes move from the Valley to winter sites farther south and west during November and December (unpubl. data, Idaho Coop. Wildl. Res. Unit).

Of nine winter sightings, six were from southwestern New Mexico (Columbus area), southeastern Arizona (Willcox Playa area), and adjacent areas in northwestern Chihuahua, Mexico (Table 1, Fig. 1). Four of these six sightings were made during the first winter following banding. Three other cranes were observed in the Rio Grande Valley, in Valencia and Socorro counties, New Mexico, 2, 4, and 11 years after marking. One crane, banded on Camas Prairie in July 1972, was shot south of Ft. Sumner, New Mexico, during the 1976 hunting season. This location is within the principal winter range of lesser sandhill cranes (*G. c. canadensis*) in the Pecos River Valley, New Mexico (Lewis 1977). Only small groups of the greater subspecies normally winter in the Pecos Valley in company with the more numerous lesser subspecies.

Table 1. Greater sandhill cranes captured and color-marked on nesting grounds in southcentral Idaho, 1971-1974, and subsequently reported during migration or on winter areas in Colorado, New Mexico, Arizona, and Chihuahua, Mexico. Locations are shown in Fig. 1.

Banding location	No. banded and color-marked	Crane no.	Observation date and location	Report[a]
Camas Prairie, Camas County	28	1	8 Mar 73, Las Vegas NWR, San Miguel Co., NM	Spring migration
		2	6 Jan 75, near Columbus, Luna Co., NM	Winter
		3	7 Jan 75, Willcox Playa, AZ	Winter
		3	7 Mar 77, Bosque del Apache NWR, Socorro Co., NM	Spring migration
		4	13 Mar 75, San Luis Valley, Alamosa Co., CO	Spring migration
		5	13-16 Mar 75, San Luis Valley, Alamosa Co., CO	Spring migration
		6	14 Dec 76, south of Ft. Sumner, DeBaca Co., NM	Winter
		7	20 Nov 84, Casa Colorado State Refuge, Valencia Co., NM	Fall migration or winter
Silver Creek, Blaine County	3	8, 9[b]	6 Jan 75, near Columbus, Luna Co., NM	Winter
		10	1, 15 Dec 78, Bernardo State Refuge, Socorro Co., NM	Winter
Sawtooth Valley, Blaine and Custer counties	5	No reports		
Chilly Slough, Custer County	4	11	5 Dec 75, Bernardo State Refuge, Socorro Co.,	Winter
		12	30 Nov 77, 12-15 Dec 77, Polvadera, Socorro Co., NM	Winter
Upper Little Wood River, Blaine County	3	No reports		
Southcentral Idaho[c]		13	4 Jan 79, Galeana, Chihuahua, Mexico	Winter
		14	5 Jan 79, Ascension, Chihuahua, Mexico	Winter

[a] Visual sightings except crane ID 6 that was shot.
[b] Brood containing two marked individuals.
[c] Exact source of individuals 13 and 14 was not ascertained.

Four spring migration sightings were obtained. Two, in March 1975, were in the San Luis Valley, Colorado, the major spring stopover area for the Rocky Mountain population (Drewien and Bizeau 1974). Another crane was observed with a migrating flock which had arrived from the south in March 1977 at Bosque del Apache National Wildlife Refuge, New Mexico. A crane banded in July 1972 was observed in March 1973 at Las Vegas National Wildlife Refuge in northeastern New Mexico during spring migration. This refuge is located east of the principal spring migration route of the Rocky Mountain population. However, small numbers of this population utilize the refuge during both the fall and spring migration and during some winters. A color-marked crane from Grays Lake National Wildlife Refuge in southeastern Idaho was also present in the flock of the migrants containing the Camas Prairie bird.

CONCLUSIONS

Southcentral Idaho cranes apparently are affiliated with the Rocky Mountain population. Winter records are scattered from eastern New Mexico westward to southeastern Arizona and into northern Mexico. However, most winter sightings are south and west of the population's principal winter range in the middle Rio Grande Valley, New Mexico. Based upon limited sight records, southcentral Idaho cranes tended to concentrate along the Mexico border near Columbus, New Mexico, the Willcox Playa in southeastern Arizona, and in northwestern Chihuahua, Mexico. Very few sightings (December-early February) of the southcentral Idaho cranes have been recorded in the Rio Grande Valley, New Mexico, the area that we have intensively surveyed each winter since 1971.

The major fall and spring migration route of the Rocky Mountain population passes through northeastern Utah, western and southcentral Colorado, including the San Luis Valley (Drewien and Bizeau 1974, 1981, Lewis 1977, Drewien et al. this Proceedings). We have no observations of southcentral Idaho cranes along this route except for two sightings in the San Luis Valley. Consequently, we suspect that most southcentral Idaho cranes follow a more westerly migration route that passes through Utah to southeastern Arizona, southwestern New Mexico, and into Chihuahua, Mexico.

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FORAGING AND MAINTENANCE BEHAVIORS OF SANDHILL CRANES[1]

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Abstract: Many maintenance behaviors of sandhill cranes (Grus canadensis) are stereotyped in performance. Acquisition of essential nutrients, comfort movements, and locomotor activities accounted for over 85% of diurnal time expenditures of sandhill cranes. Juvenile sandhill cranes apparently benefited directly from parental investment through reduced time spent searching for food and increased time spent gleaning small grains. Mated adults spent a lower percentage of time gleaning and a higher percentage of time exhibiting social signals than adults without mates. Adult males spent a higher percentage of time exhibiting social signals; searched, gleaned, and probed for shorter periods; slept less frequently and for shorter periods; and were more mobile then adult females.

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Maintenance behaviors are general or specific activities (including comfort movements) that serve to maintain an animal physiologically (Marler 1956). The purpose of this paper is to provide a quantitative description of the maintenance behaviors of sandhill cranes (Grus canadensis). These descriptions will aid in interpreting the evolution of social signals in sandhill cranes and for comparative studies of other gruids. Quantification of maintenance behaviors will aid in interpreting parental investment patterns (Trivers 1972) and social organization of migrating and wintering cranes.

I thank P. A. Vohs for his encouragement, advice, and assistance throughout this study. P. A. Vohs and M. W. Weller reviewed the manuscript. I am grateful to G. C. Iverson and D. C. Martin for assistance during field work and providing valuable discussions about cranes. I thank W. D. Warde for assistance with statistical analyses.

METHODS

Maintenance behaviors of sandhill cranes were studied from early January through February 1978 to 1980 near Rich Lake, Terry County, Texas, and during March and early April 1978 to 1980 along the Platte River between Sutherland and North Platte, Nebraska. Additional observations were made during the last 2 weeks of April 1980 near the north end of Last Mountain Lake, Saskatchewan; during May 1980 near Delta Junction, Alaska; and immediately before nesting in May 1980 near Old Chevak, Clarence Rhode National Wildlife Refuge, Alaska.

Observations were aided with a 15 x 60 telescope. Postures and movements were recorded on 35 mm slides and 16 mm motion pictures in 1978. Descriptions and social interactions were verbally recorded on tape during 1,109 20-minute time budgets in 1979 and 1980. Behaviors recorded were the maintenance categories defined in this paper and the social signals defined elsewhere (Tacha 1981).

Juvenile (young-of-the-year) sandhill cranes were distinguished from adults by their brown nape (Lewis 1979). Sex of some cranes was determined in the field by observation of the unison call (described by Archibald 1975). Sex was designated during 54 time budgets for members of a pair on the basis of females following males and later verified by observation of the unison call. None of the designations made on the basis of the female following the male was found to be incorrect during the subsequently observed calls. The observation of one crane of a pair following another for extended periods was used to assume sex in time budgets where the unison

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[1] This study was funded by Contract 14-18-0008-2133, Accelerated Research Program for Migratory Shore and Upland Game Birds, administered by the Central Management Unit Technical Committee and the Migratory Bird and Habitat Research Laboratory, U. S. Fish and Wildlife Service.

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call was not observed. Pairs (two adults) and family units (two adults and one or two juveniles) were identified by their close proximity (compared to other cranes in larger flocks), the tendency for adult females of pairs to follow the male, and the propensity of juveniles of family units to follow their parents. The sex of juveniles could not be determined in the field, and no juveniles were observed as members of a mated pair. The sex of adults not in pairs or family units could not be determined.

Length of behaviors were recorded to the nearest full second when time budgets were transcribed from tapes to coding sheets for subsequent computer analyses. Cranes were selected for observation and time budgets using stratified random sampling as follows: time budgets were obtained in all major habitats used by cranes at all hours of the day, sampling was stratified by age groups to insure adequate sampling of juveniles, and cranes marked (neck collar and leg band) less than 7 days were not sampled. Statistical tests were performed using the Statistical Analysis System (Barr et al. 1979). Three methods of quantifying behaviors used were: frequency of occurrence of behaviors using each time budget as an experimental unit and recording presence or absence of each behavior; duration of each behavior using each observation of the behavior in a time budget as the experimental unit; and the percentage of total time spent exhibiting each behavior using time budgets as the experimental units. Observed Significance Levels (OSL) less than 0.05 were considered sufficient to reject statistical hypotheses.

RESULTS

Foraging

Searching, gleaning, probing, and drinking were grouped as foraging activities. Frequency of occurrence of foraging activities did not vary between age, sex, or social classes (Tables 1-3). Juveniles spent 1.25 times the percentage of time spent foraging by adults, and adult females spent a higher percentage of time (64%) foraging than adult males (53.9%, Table 4). Adults in pairs and family units spent 1.14 times the percentage of time that adults without mates or young spent foraging (Table 5).

Table 1. Comparison between age and sex classes of the percentage occurrence of maintenance behaviors in time budgets of sandhill cranes.

Behaviors[a]	Age				Sex			
	Adult (N=711)	Juvenile (N=399)	Z	OSL[b]	Male (N=150)	Female (N=141)	Z	OSL
Searching	85.51	85.84	0.14	0.888	92.67	89.36	0.99	0.323
Gleaning	30.24	34.22	1.30	0.194	21.33	20.57	0.16	0.873
Probing	70.32	67.55	0.91	0.362	82.00	87.94	1.41	0.158
Drinking	5.77	3.54	1.54	0.123	8.00	4.26	1.33	0.185
Foraging	90.72	93.51	1.53	0.127	95.33	95.04	0.12	0.906
Loafing	77.78	70.80	2.46	0.014	69.33	64.54	0.87	0.385
Sleeping	11.39	5.60	2.99	0.003	5.33	12.06	2.05	0.041
Preening	54.85	41.89	3.93	0.001	54.00	41.13	2.20	0.028
Stretching	14.21	13.86	0.15	0.882	8.67	13.48	1.31	0.190
Flying	18.14	16.52	0.65	0.518	17.33	20.57	0.70	0.481
Walking	71.87	61.95	3.24	0.001	77.33	63.83	2.53	0.011
Locomotor	75.67	66.37	3.16	0.002	80.67	68.79	2.33	0.020

[a] Foraging includes searching, gleaning, probing, and drinking; Loafing includes loafing-up and loafing-down; Sleeping includes sleeping-up and sleeping-down; Preening includes preening wings, neck, chest, back, head rub, head scratch, and body shake; Stretching includes wing and leg stretch, wing flap, and double wing stretch; and Locomotor behavior includes flying, soaring, walking, and running.

[b] Observed significance levels.

Table 2. Comparison between social classes of adults and juveniles of the percentage occurrence of maintenance behaviors in time budgets of sandhill cranes.

	Adults					Juveniles			
Behavior[a]	Alone (N=128)	Pair (N=57)	Family (N=180)	X^2	OSL	Alone (N=62)	Family (N=210)	X^2	OSL
Searching	80.4	92.9	87.7	6.04	0.04	90.3	86.6	0.76	0.04
Gleaning	32.8	26.3	17.2	10.12	0.00	19.3	34.2	2.24	0.02
Probing	74.2	75.4	86.1	7.68	0.02	80.6	66.6	2.11	0.03
Drinking	10.9	0.0	7.7	6.67	0.03	6.4	2.86	1.32	0.18
Foraging	91.4	92.9	93.3	0.42	0.81	93.5	96.1	0.89	0.37
Loafing	82.0	61.4	62.2	15.58	0.00	56.4	69.5	1.92	0.05
Sleeping	13.2	1.75	8.8	6.28	0.04	9.6	5.7	1.10	0.27
Preening	63.2	42.1	43.8	13.12	0.00	40.3	36.1	0.59	0.55
Stretching	18.7	8.7	8.8	7.52	0.02	14.5	14.2	0.04	0.96
Flying	14.0	19.3	20.0	1.90	0.38	14.5	13.3	0.24	0.81
Walking	71.8	71.9	62.7	3.45	0.78	53.2	60.9	1.09	0.27
Locomotor	75.7	73.6	67.7	2.51	0.28	56.4	64.7	1.19	0.23

[a] See footnotes for Table 1.

Table 3. Comparison between age and sex classes of duration of sandhill crane maintenance behaviors (measured in seconds).

	Adult males[a]			Adult females			Juveniles			ANOVA[b]		
Behavior	N	x	SE	N	x	SE	N	x	SE	EMS	F	OSL
Searching	1031	8.52	0.56*	673	10.77	0.72	1731	9.41	0.4	312.61	3.32	0.036
Gleaning	208	67.03	6.02	103	95.94	15.01*	839	105.01	5.53	22,167.49	5.43	0.005
Probing	941	80.69	3.07*	678	135.14	6.88	1276	133.70	5.41	26,889.74	33.83	0.001
Drinking	15	28.67	6.50	6	29.00	14.05	20	28.20	5.66	709.54	0.00	0.997
Loafing												
Up	546	43.73	4.40*	467	29.08	2.49	1493	33.31	2.18	7,091.14	4.38	0.013
Down	5	229.20	112.15*	3	673.67	296.22*	22	172.55	53.18	77,213.96	4.29	0.024
Sleeping												
Up	11	224.64	58.28	25	298.60	81.16	23	402.43	79.89	134,915.57	1.03	0.365
Down	3	39.00	17.04	2	1200.00	0.00*	8	231.13	114.83	74,016.29	12.47	0.002
Preening												
Wings	156	37.68	3.39	168	34.56	2.96	456	34.68	2.03	1,772.09	0.32	0.723
Neck	7	24.86	9.30	11	16.82	4.08	76	13.76	2.09	333.37	1.25	0.292
Chest	26	9.92	1.80	26	11.31	1.77	72	16.10	2.47	291.55	1.60	0.206
Back	26	19.58	3.52*	4	9.50	2.22	61	11.51	1.40	173.21	3.64	0.030
Head rub	40	7.58	1.18	28	6.11	0.73	140	5.99	0.48	34.81	1.15	0.320
Head scratch	24	10.54	2.43*	22	7.32	1.22*	75	5.75	0.42	41.79	5.04	0.008
Body scratch	30	2.93	0.43	27	2.18	0.36	88	3.00	0.40	10.48	0.67	0.512
Stretching												
Wing/leg	14	7.50	0.90	18	7.00	0.66*	48	5.40	0.33	6.92	4.75	0.011
Wing flap	4	7.00	1.68*	1	2.00	0.00	12	3.67	0.53	5.05	3.88	0.046
Double wing	2	5.50	1.50	9	3.33	0.37	22	3.91	0.41	3.01	1.32	0.283
Locomotion												
Flying	28	110.93	29.93	31	78.84	10.36	60	116.33	16.73	15,242.74	0.98	0.378
Soaring	2	833.00	367.00	1	340.00	0.00	2	446.50	145.50	155,859.25	0.71	0.585
Walking	463	24.09	1.62	312	24.22	2.40	870	24.64	1.46	1,656.65	0.03	0.969
Running	1	1.00	0.00	1	5.00	0.00	17	8.71	1.93	63.47	0.52	0.603

[a] *Differences between adjacent means, $P < 0.05$, from Duncans Multiple Range Test.
[b] ANOVA = analysis of variance.

Table 4. Comparison between sandhill crane age and sex classes of percentage of time spent exhibiting maintenance behaviors.

	Adults (N=711)			Juveniles (N=339)		Males (N=150)			Females (N=141)	
Behavior	x	SE	OSL	x	SE	x	SE	OSL	x	SE
Foraging										
Searching	4.728	0.301	0.038[a]	3.819	0.315	4.844	0.778	0.562[a]	4.258	0.645
Gleaning	12.083	0.947	0.001[a]	20.116	1.859	7.779	1.675	0.405	5.840	1.605
Probing	34.409	1.314	0.016[a]	40.423	2.109	41.038	2.592	0.001	54.103	3.076
Drinking	0.216	0.049	0.293[a]	0.139	0.054	0.239	0.085	0.197[a]	0.103	0.062
Total	51.433	1.305	0.001	64.497	1.857	53.901	2.453	0.006	64.305	2.849
Loafing										
Up	14.635	0.791	0.002[a]	10.087	0.948	11.106	1.482	0.030[a]	6.991	1.175
Down	1.101	0.326	0.603[a]	0.852	0.351	0.166	0.128	0.257[a]	1.091	0.803
Total	15.736	0.841	0.003[a]	10.938	1.005	11.272	1.501	0.121	8.082	1.384
Sleeping										
Up	5.121	0.692	0.001[a]	2.065	0.628	1.373	0.602	0.016[a]	5.836	1.730
Down	1.023	0.324	0.199[a]	0.455	0.302	0.006	0.006	0.150[a]	1.418	0.999
Total	6.144	0.756	0.004[a]	0.000	0.000	-	-	-	-	-
Bathing	0.008	0.006	0.168[a]	0.000	0.000	-	-	-	-	-
Preening										
Wings	4.420	0.413	0.153[a]	3.466	0.524	3.175	0.661	0.874	3.024	0.069
Neck	0.297	0.070	0.698[a]	0.257	0.077	0.097	0.061	0.992	0.098	0.059
Chest	0.215	0.029	0.373[a]	0.284	0.072	0.128	0.045	0.770[a]	0.150	0.062
Back	0.159	0.036	0.993	0.159	0.050	0.272	0.132	0.056[a]	0.015	0.010
Head rub	0.258	0.057	0.491[a]	0.199	0.062	0.169	0.074	0.099[a]	0.043	0.019
Head scratch	0.144	0.019	0.129[a]	0.105	0.017	0.141	0.053	0.185[a]	0.065	0.019
Body shake	0.082	0.009	0.041[a]	0.053	0.011	0.047	0.012	0.418[a]	0.035	0.009
Total	6.234	0.500	0.285	5.308	0.689	4.896	0.872	0.357	3.781	0.832
Stretching										
Wing and leg	0.059	0.009	0.788[a]	0.055	0.011	0.058	0.020	0.626[a]	0.074	0.026
Wing flap	0.017	0.006	0.143[a]	0.007	0.003	0.016	0.009	0.125[a]	0.001	0.001
Double wing	0.014	0.003	0.482	0.018	0.005	0.006	0.006	0.193	0.018	0.006
Total	0.089	0.011	0.581[a]	0.079	0.013	0.080	0.025	0.721	0.093	0.028
Locomotion										
Flying	1.938	0.261	0.536[a]	1.683	0.316	1.926	0.602	0.676[a]	1.444	0.299
Soaring	0.355	0.173	0.568[a]	0.220	0.163	0.926	0.714	0.330[a]	0.201	0.201
Walking	4.714	0.290	0.214	4.083	0.411	6.123	0.657	0.052	4.251	0.698
Running	0.004	0.001	0.029[a]	0.034	0.014	0.001	0.001	0.426[a]	0.003	0.003
Total	7.047	0.420	0.139[a]	6.018	0.552	8.774	1.093	0.035[a]	5.899	0.803
Out of sight	6.714	0.535	0.366	5.905	0.708	5.571	1.138	0.450	6.811	1.182
Total Maintenance	86.690	0.646	0.011[a]	89.359	0.646	80.301	1.544	0.001	89.415	1.425

[a] Unequal variances, $P < 0.05$.

Table 5. Comparison of percentages of time spent exhibiting maintenance behaviors among social classes of adult and juvenile sandhill cranes.

	Adults[a]					Juveniles				
				AOVA		Alone (N=62)			Family (N=210)	
Behavior	Alone (N=128)	Pair (N=180)	Family (N=57)	EMS	OSL	x	SE	OSL	x	SE
Foraging										
Searching	4.403	3.213	2.656	0.003	0.074	5.441	1.105	0.012[b]	2.517	0.215
Gleaning	11.752[c]	4.997	8.975	0.040	0.014	10.210	3.240	0.003[b]	22.537	2.502
Probing	32.143[c]	52.186	44.186	0.119	0.001	47.090	4.680	0.647	44.443	2.817
Drinking	0.524	0.253	0.000	0.257[a]	0.010	0.140	0.076	0.815[b]	0.117	0.057
Total	48.822[c]	60.519	55.817	0.114	0.012	62.880	4.488	0.160	69.614	2.232
Loafing										
Up	18.315[c]	6.601	13.341	0.035	0.001	5.859	1.532	0.027[b]	10.185	1.185
Down	3.701[c]	0.911	0.000	0.013	0.044	1.254	1.150	0.841[b]	1.004	0.445
Total	22.015[c]	7.512	13.341	0.044	0.001	7.113	1.857	0.072[b]	11.190	1.269
Sleeping										
Up	5.383	5.184	1.754	0.036	0.435	5.219	2.568	0.183[b]	1.654	0.652
Down	0.697	1.390	0.000	0.008	0.537	1.493	1.493	0.429[b]	0.293	0.208
Total	6.079	6.574	1.754	0.042	0.293	6.712	2.927	0.117[b]	1.947	0.681
Bathing	0.027	0.000	0.000	0.003[a]	0.397	-	-	-	-	-
Preening										
Wings	5.671	3.220	2.950	0.009	0.051	6.651	1.892	0.041[b]	2.560	0.528
Neck	0.752	0.180	0.085	0.001	0.078	0.144	0.078	0.190[b]	0.332	0.120
Chest	0.294	0.123	0.151	0.050[a]	0.105	0.483	0.279	0.279[b]	0.171	0.058
Back	0.158[c]	0.009	0.070	0.006[a]	0.008	0.000	0.000	0.009[b]	0.117	0.044
Head rub	0.307[c]	0.029	0.032	0.098[a]	0.039	0.022	0.013	0.062[b]	0.083	0.030
Head scratch	0.170	0.131	0.010	0.022[a]	0.104	0.038	0.018	0.012[b]	0.113	0.024
Body shake	0.121[c]	0.025	0.034	0.005[a]	0.001	0.022	0.008	0.165[b]	0.040	0.011
Total	7.521[c]	3.723	3.439	0.012	0.006	7.360	2.066	0.073[b]	3.438	0.614
Stretching										
Wing and leg	0.058	0.050	0.038	0.004[a]	0.796	0.036	0.022	0.329	0.062	0.013
Wing flap	0.046	0.000	0.000	0.004[a]	0.128	0.011	0.008	0.336[b]	0.002	0.002
Double wing	0.027	0.010	0.021	0.001[a]	0.360	0.022	0.011	0.852	0.019	0.006
Total	0.132	0.059	0.059	0.009[a]	0.097	0.069	0.027	0.654	0.084	0.017
Locomotion										
Flying	1.429	1.369	1.398	1.951[a]	0.993	0.884	0.311	0.303[b]	1.414	0.409
Soaring	0.135	0.216	0.000	0.497[a]	0.811	1.200	0.887	0.181[b]	0.000	0.000
Walking	3.328	4.354	4.016	0.004	0.352	3.831	0.844	0.326[b]	2.925	0.358
Running	0.010	0.002	0.007	0.001[a]	0.380	0.071	0.055	0.475[b]	0.031	0.015
Total	4.903	5.940	5.421	0.006	0.531	5.987	1.299	0.255[b]	4.368	0.551
Out of sight	7.018	6.724	9.583	0.021	0.421	3.410	1.315	0.201	5.667	0.873
Total maintenance	89.499[c]	84.327	79.830	0.034	0.003	90.121	1.499	0.788[b]	90.640	1.070

[a] Multiply EMS by 10^{-3}.
[b] Unequal variances, $P < 0.05$.
[c] Differences between adjacent means, $P < 0.05$, Duncans Multiple Range Test.

Searching. - Sandhill cranes exhibited a stereotyped food-searching posture (Fig. 1a). The body was held on a horizontal plane, the neck curved downward and the bill held near a 45° below horizontal. This food-searching posture was observed at all locations and in all habitats where cranes attempted to feed.

No difference in frequency of occurrence (Table 1) or duration (Table 3) of searching behaviors was observed between adult and juvenile sandhill cranes. However, adults of both sexes spent a higher percentage of time (4.72%) searching for food than did juveniles (3.82%, Table 4). Adult males searched for periods 80% as long as adult females (Table 3), but frequency of occurrence (Table 1) and percentage of time searching (Table 4) did not differ between sexes. Adult cranes in pairs and family units searched more frequently than adults without mates or young (Table 2) but the percentage of time spent searching did not vary between social classes (Table 5).

Gleaning. - The retrieval and/or ingestion of food items from the surface of the medium upon which a crane is feeding is called gleaning (Fig. 1b). Gleaning was the major method of feeding in harvested small grain fields or other areas where surface food items were abundant. Posture of the body while gleaning was similar to that of searching but cranes moved their heads from side to side while walking forward, ingesting food items as they walked.

Juvenile sandhill cranes were observed gleaning with the same frequency as adults (Table 1) but juveniles gleaned for 10% longer periods (Table 3). Juveniles spent nearly twice the percentage of time gleaning (Table 4) as adults. Differences in frequency of occurrence (Table 1), duration (Table 3), or percentage of time (Table 4) spent gleaning were not observed between sexes of adult cranes. Adults without mates or young gleaned 1.25 times as frequently (Table 2) and spent 1.3 times the percentage of time gleaning (Table 5) as did adults in pairs or family units. Juveniles in family units gleaned nearly twice as frequently (Table 2) and spent 1.3 times the percentage of time gleaning (Table 5) as did adults in pairs of family units. Juveniles in family units gleaned nearly twice as frequently (Table 2) and spent twice the percentage of time gleaning (Table 5) as did juveniles without parents.

Probing. - Probing was used by sandhill cranes to locate and extract subsurface food items (Fig. 2). A typical performance included a vertical (10 cm) hammering motion of the head and bill (Fig. 2a above) to dislodge soil or break up stems and roots. Loose particles from the probing site were removed with a lateral flip of the head in about a 30 degrees arc (Fig. 2b). Lateral compression of the bill made side to side particle removal more efficient than forward or backward movements. Movements of the head and neck were variable. Films at 24 fps did not record all movements in probing when peak rates of head movements were achieved. As a crane began to probe, movements were usually deliberate and methodical. As probing continued, rates of vertical strokes exceeded my ability to see the individual motions.

Cranes rarely probe deeper into a substrate than the distance from the tip of the bill to the crown of the head (100-150 mm). However, cranes often probed in mud in shallow ponds as much as 0.3 m below the surface of the water. Juveniles in families often probed in the same hole as their female parent. Adult females were observed to feed invertebrates (resulting from probing) to young 48 times during time budgets.

No differences in frequency of occurrence of probing were observed between age and sex classes (Table 1). Juvenile cranes spent 1.2 times the percentage of time probing (Table 4) that adults did. Among adults, females probed for 50% longer periods (Table 3) and spent 1.25 times the percentage of time probing (Table 4) as did males. Adults without mates spent 75% as much of their time probing (Table 5) as did adults in pairs. Adult males of pairs probed 1.26 times as frequently as adult males in family units, but frequency of occurrence of probing did not vary between adult females of pairs and family units. Juveniles without parents probed 1.21 times more frequently than juveniles with parents (Table 2), but juveniles with and without parents spent approximately the same percentage of time probing (Table 5).

Drinking. - Cranes nearly always stood in water with the head and neck extended forward and down, and the lower mandible submerged (Fig. 3) before drinking. The mandibles were closed, and the head was raised above a 60° angle from horizontal during ingestion. All age, sex, and social classes of cranes spent approximately the same effort in drinking (Tables 1-5).

Loafing

Loafing (up and down combined) was observed in 75% of the time budgets (Table 1). Adults loafed 1.1 times more frequently than juveniles (Table 1), and adults without mates or young were observed loafing 1.3 times more often than adults in pairs or families (Table 2). Adults

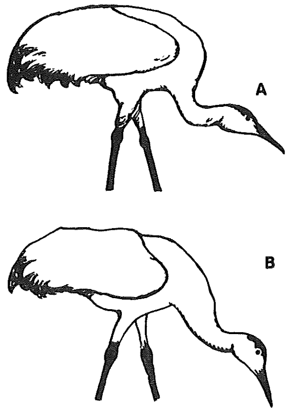

Fig. 1. Posture of sandhill cranes while (A) searching for food items and (B) gleaning food items from the surface (from 35 mm slides).

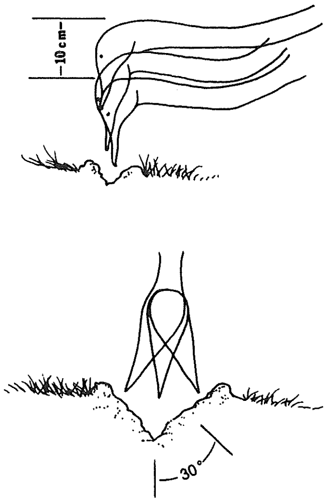

Fig. 2. Vertical and lateral movements of the head and neck when sandhill cranes probe for subsurface food items (from 35 mm slides).

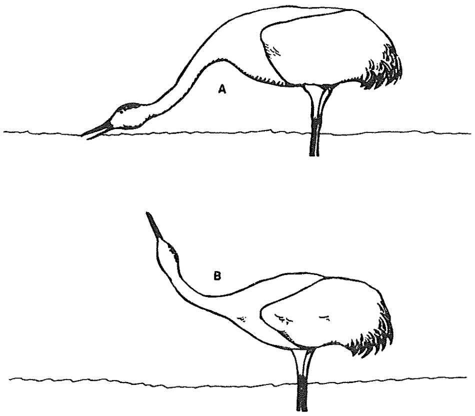

Fig. 3. Drinking movements of sandhill cranes (from 16 mm films).

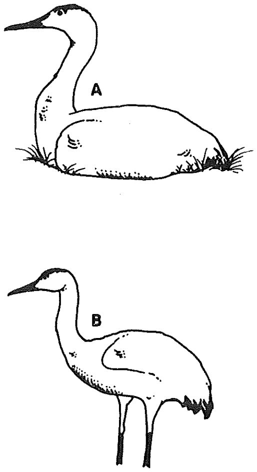

Fig. 4. Postures of sandhill cranes while (A) loafing-down and (B) loafing-up (from 35 mm slides).

spent 1.5 times more time loafing than juveniles (Table 4), and adults without mates or young spent nearly twice as much time loafing as adults in pairs and families (Table 5).

Loafing-down. - Sandhill cranes were observed to loaf-down (Fig. 4a) primarily on warm afternoons. Cranes would lie down, tuck the tarsus forward under the body, and position the head and neck in the same posture as loafing-up (Fig. 4b).

Loafing-down was observed in time budgets only 30 times (Table 3), but the duration of loafing-down varied from a mean of 229 sec among adult males to a mean of 674 sec among adults females. Adults without social bonds spent four times the percentage of time loafing-down as did adults in pairs or families (Table 5).

Loafing-up. - Sandhill cranes had a stereotyped loafing posture when standing (Fig. 4b). Loafing-up involved a stance on one or both legs, but with no locomotion. The position of the head and neck was consistant during loafing, and only a slight variation resulted in alert or threat postures.

Observations of sandhill cranes loafing-up varied from a mean duration of 29.1 sec among adult females to 43.73 sec among adult males (Table 3). Adults spent a higher percentage of time (14%) loafing-up than juveniles (10%), and adult males spent more time (11%) loafing-up than did adult females (7%, Table 4). Adults without mates spent three times more time loafing-up than adults in pairs, and juveniles in families spent twice the time loafing-up as did juveniles without parents (Table 5).

Sleeping

Sleeping (up and down combined) was observed in 9% of time budgets, with adults sleeping twice as frequently as juveniles and adult females sleeping twice as frequently as adult males (Table 1). Adult cranes in pairs were observed sleeping four times less often than adults of family units or adults without mates or young (Table 2). Adults spent nearly three times the percentage of time sleeping as did juveniles, and adult females slept five times as high a percentage of time as adult males (Table 4).

Sleeping-up. - Sandhill cranes had a stereotyped sleeping posture (Fig. 5a). The head was turned back over a shoulder and the bill tucked under the scapular feathers, often while standing on 1 leg.

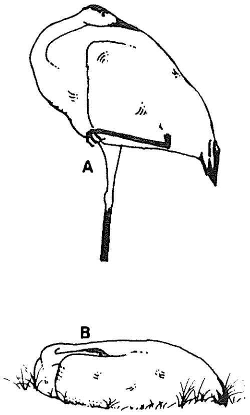

Fig. 5. Postures of sandhill cranes while (A) sleeping-up and (B) sleeping-down (from 35 mm slides).

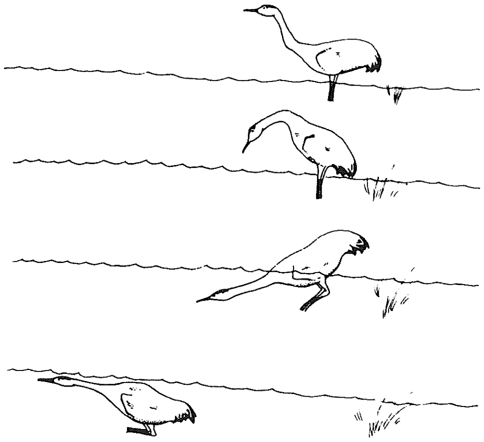

Fig. 6. Movement pattern of a sandhill crane while bathing (freehand drawing).

Fig. 7. Wing preening by a sandhill crane (from 35 mm slides).

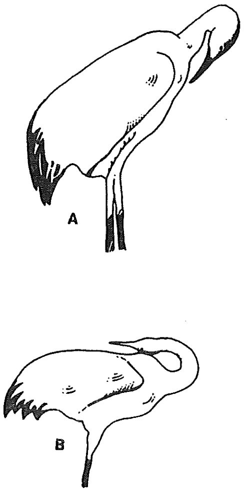

Fig. 8. Chest preening (A) and head rub (B) movements of sandhill cranes (from 16 mm films).

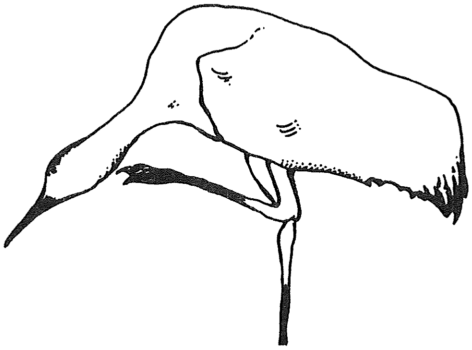

Fig. 9. Scratching movement of a sandhill crane (from 35 mm slides).

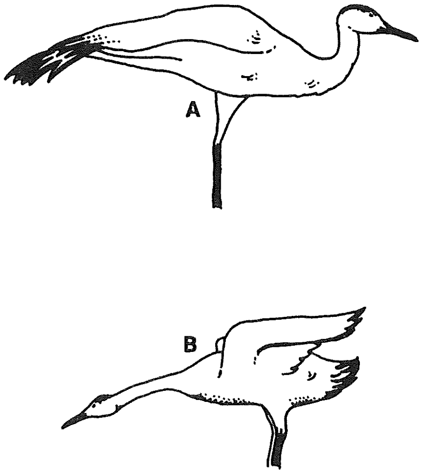

Fig. 10. Wing-and-leg (A) and double wing (B) stretches of sandhill cranes (from 16 mm films).

Cranes slept for extended periods (Table 3), often for all of a 20-minute time budget. Adults spent twice the percentage of time sleeping-up that juveniles did, and adult females slept-up four times more than males (Table 4). The percentage of time spent sleeping-up did not vary between social classes (Table 5).

Sleeping-down. - During the day, sandhill cranes were often observed to be sleeping-down (Fig. 5b). After a period of loafing-down, cranes would tuck their bill under scapular feathers, resulting in the sleeping-down posture.

Adult females slept-down for six times longer periods than adult males or juveniles (Table 3). No differences in percentage of time spent sleeping-down were observed between age, sex, or social classes (Tables 4 and 5).

Bathing

Sandhill cranes were observed bathing during only four time budgets. Cranes waded into water 20-40 cm deep, submersed themselves in a quick diving motion (Fig. 6), and often rolled in water following the initial diving motion. Following immersion, cranes would wade from the water while alternately body shaking and flapping. A prolonged preening session followed the shaking and flapping. Bathing was only observed among adults in time budgets (Table 4), and sample sizes were too small for analysis by age, sex, or social classes.

Preening

When all forms of preening were combined, adults preened 1.3 times more frequently than juveniles, and males preened 1.3 times more frequently than females (Table 1). Adults without mates or young preened 1.5 times more frequently (Table 2) and spent twice as much time preening (Table 5) as adults in pairs or families.

Preening the Wings. - The wing preen followed spreading of the wings. Coverts and upperwing feathers were preened in a nibbling movement (Fig. 7). Contour feathers were grasped between the distal ends of the mandibles, and the individual feathers were stroked from calamus to tip while the wing was half extended.

Wing preening lasted an average of 35 sec (Table 3). No differences in percentage of time spent preening wings were observed between age, sex, or social classes (Tables 4 and 5).

Preening the Neck. - Sandhill cranes preen the lower half of their neck using a nibbling motion with the bill. Duration of neck preening did not vary between age and sex classes (Table 3). No differences in percentage of time spent preening the neck were observed between age, sex, or social classes (Tables 4 and 5).

Preening the Chest. - Sandhill cranes preened the chest and abdomen feathers with a nibbling motion (Fig. 8a). Duration of chest preening bouts did not vary between age and sex classes (Table 3). No differences in percentage of time spent preening the chest were observed between age, sex, or social classes (Tables 4 and 5).

Preening the Back. - Sandhill cranes preened the area of the back between the wings in short bouts (Table 3). Adult males preened the back for periods twice as long as adult females or juveniles. Adults without mates or young spent over 10 times more time preening the back than adults in pairs or families (Table 5).

Head Rub. - The head rub (Fig. 8b) served to preen the feathers of the back of the head and to distribute oil from the europigial gland on feathers. Cranes would rub the back of the head on the europigial gland and then on feathers of the wings and back. I did not observe cranes oiling neck or chest feathers with the bill.

Head rubbing was exhibited for short periods (Table 3). Adults without mates or young exhibited the head rub 10 times the percentage of time observed for adults in pairs or families (Table 5).

Head Scratch. - Scratching of the upper neck, head, and bill was accomplished using the claw on the middle toe of either foot (Fig. 9). The head and neck were stretched forward and downward 20-30° during scratching. The head was often rotated as much as 120° to make all parts of the head and upper half of the neck available to be scratched.

Head scratching bouts lasted 5-10 sec, with adult males scratching 50% longer periods than adult females and adult females scratching 50% longer periods than juveniles (Table 3). The percentage of time spent scratching did not vary between ages or sexes (Table 4); however, juveniles in family units spent nearly three times as much time scratching as did juveniles without parents (Table 5).

Body Shake. - The body shake was a movement apparently intended to rearrange feathers of the body and wings of sandhill cranes. Body shaking was nearly always performed after flights, more exerting social signals, or bathing. The feathers of the body were erected while the crane violently shook. Cranes often began to preen their wings after a body shake.

Body shaking occurred for only 1-5 sec (Table 3). Adults spent 1.5 times more time exhibiting the body shake than juveniles (Table 4), but percentage of time spent exhibiting the body shake did not vary between sexes. Adults without mates or young spent 10 times more time body shaking than adults in pairs or family units (Table 5).

Stretching

Frequency of occurrence of all three forms of stretching did not differ between age and sex classes (Table 1). However, adults without mates or young stretched twice as frequently as adults in pairs or families (Table 2). A difference in percentage of time spent stretching was not observed between age, sex, or social classes (Tables 4 and 5).

Wing-and-leg Stretch. - During the wing-and-leg stretch, the wing on one side was fully extended while the leg on the same side was stretched backward (Fig. 10a). This position was held for several seconds, then the wing was folded and the leg returned to the ground.

The wing-and-leg stretch lasted 4-8 sec, with juveniles stretching for 30% shorter periods than adults (Table 3). A difference in the percentage of time spent in wing-and-leg stretching was not observed between age, sex, or social classes (Tables 4 and 5).

Wing-flapping. - Wing-flapping consisted of vigorously flapping fully extended wings while standing with the body in a 60° upright position. Wing-flapping apparently functioned to stretch flight muscles and to shed excess water after bathing. Wing-flapping was often used as a displacement activity or preceding flight.

Wing-flapping bouts lasted from 2 to 10 sec (Table 3). Adult males wing-flapped for periods twice as long as adult females or juveniles. A difference was not observed between age, sex, or social classes, in percentage of time spent wing-flapping (Tables 4 and 5).

Double Wing Stretch. - During the double wing stretch, the head was stretched forward and downward in line with the body axis at about a 20-30° angle below horizontal, while both wings wre raised (but not extended) upward and backward (Fig. 10b).

The double wing stretch lasted from 3-7 sec (Table 3) and rarely occurred other than when cranes awakened in the morning on the roost. No differences in percentage of time spent in the double wing stretch were observed between age, sex, or social classes (Tables 4 and 5).

Locomotion

Locomotion behaviors were observed in 72% of time budgets, with adults using locomotor behaviors 15% more frequently than juveniles, and adult males exhibited locomotor activities 20% more frequently than adult females (Table 1). Frequency of occurrence of locomotor activities did not differ between social classes (Table 2). Males spent 50% more time in locomotor activities than females, but percentage of time spent exhibiting locomotor behaviors did not vary between ages or social classes (Tables 4 and 5).

Flying. - Sandhill cranes normally became airborne by running 3-6 steps. However, cranes sprang directly into the air when frightened. Sandhill cranes landed on extended legs (from their trailing position during flight) after reducing air speed to nearly zero by rapid wing strokes. Legs were bent slightly upon contact with the ground, absorbing the shock of landing. Cranes took off and landed into the wind except when escaping danger.

No differences in frequency of occurrence of flight were observed between age, sex, or socail classes (Table 1). Flight averaged 110 sec in time budgets (Table 3), but this estimate was low because flight was often the terminal behavior in a time budget. As expected, no differences in percentage of time spent in flight were observed between age, sex, or social classes (Tables 4 and 5).

Soaring. - Sandhill cranes soared with wings outstretched and without wing beats. The head, neck, and legs were outstretched as when flying.

Sandhill cranes soared for prolonged periods before migration in late February and early March but duration of soaring did not differ between age and sex classes (Table 3). Differences were not detected in percentage of time spent soaring between age, sex, or social classes (Tables 4 and 5).

Walking. - Sandhill cranes walked in a deliberate manner with wings folded, each foot lifted and placed in front of and to the proper side of the other. The head moved slightly forward and back with each step. Pace length varied by size of the bird but averaged 12-15 cm. The birds did not hop.

Walking occurred in 71% of time budgets; adult males walked 1.16 times more frequently than adult females (Table 1). Differences in durations or percentages of time spent walking were not observed between age, sex, or social classes (Tables 3-5).

Running. - Movement of sandhill cranes while running resembled walking except that the pace was faster and the head was lowered slightly for balance. Running (outside a social signal context) was rarely observed among sandhill cranes (Table 5). Juveniles spent eight times more time running than adults (Table 4), but percentage of time spent running did not differ between sexes or social classes (Tables 4 and 5).

Swimming. - Sandhill cranes were observed to swim in water and floated erect and balanced (much like Fig. 4a), with about 25% of the body submerged. Cranes swam with alternating strokes of the feet much as anatids do, but forward progress was slow due to lack of webbed feet. Cranes were never observed swimming during time budgets.

Maintenance Behaviors

Adult and juvenile cranes spent 86.7% and 89.4% of their time respectively, using maintenance behaviors (Table 4). Females spent 10% more time in maintenance activities than males. Adults without mates or young spent a higher percentage of time (89.5%) in maintenance activities than adults in pairs (84.3%) or family units (79.8%) (Table 5).

DISCUSSION AND CONCLUSIONS

One of the attributes of K-selected species is lengthy parental investment (Brown 1975). Juvenile sandhill cranes remain with their parents for nearly a year (Drewien 1973). Iverson (1981) found that juvenile sandhill cranes were in better physiological condition (higher lipid levels) than adults throughout winter and during early spring migration, the period when juveniles were still subject to parental investment. This study illustrated ways in which juveniles benefited from parental investment.

Juveniles in family units were able to glean without interruption for longer periods than adults, probably as a result of parental protection. I hypothesize that juveniles of family units spent less time searching than juveniles without parents because parents were able to locate areas of comparatively high food density. Direct feeding of invertebrates to juveniles by parents, and the tenacity of juveniles in following parents closely when foraging, suggest that juveniles were allowed priority access to food by parents. The higher percentage of time spent foraging by juveniles may have been related to higher nutritional needs associated with growth because juveniles did not reach full size until age 10-12 months (Tacha 1981).

Tacha (1981) hypothesized that adult male sandhill cranes from pairs and family units served a protective role directed primarily toward the mate. Adult males spent more time exhibiting social signals than females which is consistant with the theory that adult males serve a protective role for their mates. Adult females with mates were able to sleep and forage a much higher percentage of time than their mates. Adult males were more mobile than adult females, spending a higher percentage of time in locomotor activities. Adult males searched, gleaned, and probed for shorter periods and slept less frequently and for shorter periods than adult females. Males were interrupted by agonistic or alert responses to other (probably male) cranes. Loafing and sleeping-down provided the advantage of removing cranes from social interactions. Only once was a crane loafing-down or sleeping-down observed to be involved in a social interaction. Adult males spent a higher percentage of time loafing-up and a lower percentage of time loafing-down than females. Loafing-up provided a non-signaling method of observing surroundings, and the higher percentage of time spent loafing-up by males was consistent with the male protective role.

Maintenance of social bonds is expensive in time and energy (Brown 1975). Adult sandhill cranes without mates or young were able to spend more time in foraging activities that may have resulted in ingestion of more high energy foods (gleaning) than cranes with social bonds. Adult cranes with mates and young spent more time exhibiting social signals than cranes without social bonds; implying that adult cranes with social bonds were protecting those bonds via social signals. Sandhill cranes appear to have evolved a social system and resource exploitation strategies that maximize survival of young via high parental investment, and allow relatively inexperienced cranes (subadults without mates or young) to survive without social bonds that may be costly in time and energy.

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COMPARATIVE ECOLOGY AND BEHAVIOR OF EASTERN SARUS CRANES AND BROLGAS IN AUSTRALIA

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Abstract: The eastern sarus crane (Grus antigone sharpii) was discovered in Australia in 1953. Its population and range have expanded rapidly since then. The sarus and brolga crane (G. rubicunda) are sympatric in parts of northern Australia. Studies conducted during 1972 and 1984 documented the ecology of these cranes during both the wet and dry seasons. During the dry season, members of both species fed in grain fields and roosted communally, but most brolgas fed on sedge tubers in bulkuru sedge (Eleocharis dulcis) marshes. The two species rarely mixed during the dry season. Brolgas and sarus were studied during the 1984 wet season near Morr Morr Station in Queensland to compare their breeding ecologies. The brolgas preferred large marshes, while the sarus nested mainly in small or narrow marshes, but the choice of nesting areas overlapped greatly. Thirty-six sarus nests and 24 brolga nests were found. Interactions between these species during the breeding season are described and the relative strengths of the two species are discussed. The sarus crane will probably become the dominant crane in northern Australia because of it's rapid population growth and it's advantageous dry season ecology. The brolga will probably remain the dominant crane in southern Australia, where the winters are colder.

PROCEEDINGS 1985 CRANE WORKSHOP

There are currently two species of cranes living in Australia. Until 1953 the brolga was believed to be the only crane species in Australia. In that year the eastern sarus crane was identified in Queensland (Strudwick 1980, pers. comm.), indicating that the sarus may have colonized Australia recently. However, it is not clear how long the sarus has lived in Australia.

The best evidence for a recent entry into Australia by the sarus is the lack of reports of this species before 1953. It seems very unlikely that these reports would suddenly occur after the sarus had already been present for a long time. However, some aboriginal people in northern Australia have separate names for the brolga and sarus, indicating that the sarus may have reached Australia long before its recent discovery. The sarus is expanding its range in Australia and its population is growing rapidly.

However, Dr. Hugh Lavery (1985 in lit) believes that a small population of sarus could have existed for many years and then increased suddenly due to changing land uses. Most early sightings of sarus in Australia were of individuals in crop lands or pasture lands, two land use types that have expanded greatly in north Queensland in recent decades. The sarus may also have benefited from the rapid increase in freshwater impoundments in north Queensland. These impoundments have probably helped some species of waterfowl extend their ranges in Australia (Lavery 1970).

Measurements of sarus from mainland Asia (the historical range of this crane) and of eastern sarus cranes from Australia indicate that the Australian birds are larger than their Asian counterparts but have smaller head combs. In 1980 the senior author observed three male eastern sarus at the Bangkok Zoo, Thailand. These birds had been captured in southeast Asia. They were smaller than typical male sarus from Australia. The Bangkok males had head combs that averaged 197.3 mm long (range 183-215); two male eastern sarus at the International Crane Foundation (ICF), that had been captured in Australia, had 145 mm head combs (Archibald, G. W. 1980. Comparison of the sizes of mainland Asia and Australian sarus cranes, Grus antigone sharpii. Unpubl. rept. Intern. Crane Found. 2 pp.). If these small samples are representative of their parent populations, there are marked morphological differences between the mainland Asia and Australian populations of the eastern sarus. These differences raise the possibility that the two populations have been separate long enough to evolve differences. However, these differences could also be attributed to a small colonizing population of sarus that averaged larger and had smaller head combs than typical members of the Asian population. The larger size and smaller head comb of the sarus in Australia could also be the result of brolga genes in the sarus population. Sarolgas (sarus x brolga hybrids) are larger than sarus cranes and have smaller head combs (Archibald 1981), so the backcrossing of sarolgas with sarus could produce the trends found in the Australian sarus. However, hybrids appear to be rare and probably are not an important cause of these population differences.

The brolga and the sarus are closely related (Archibald 1976, Ingold 1984). It has been hypothesized that the brolga evolved from a sarus-like ancestor that colonized Australia (Archibald 1976). The presumably recent colonization of Australia by sarus cranes and their subsequent population increase raise many questions about the outcome of the interaction between the sarus and the brolga. While the eastern sarus was gaining a foothold in Australia, it was also being extirpated from most of its range in southeast Asia. Now the population in Australia is a source of stock for reintroducing this subspecies into Asia. This paper compares the ecology and behavior of the brolga and the sarus in Australia and describes the interaction between these species.

The authors thank the following persons and agencies who assisted Dr. Archibald with his travel, accommodations, and research during his trips to Australia: Mr. and Mrs. Robert Bachis, Roy Beasley, Dr. Robert Beeton, Gavin Blackman, John Henry Dick, John Forshaw, Jack Gavin, Andrew Haffenden, Peter Henzler, Mr. and Mrs. William Johns, Mr. and Mrs. Neville-Travis Jones, Dr. Hugh Lavery, Don Marshall, the Morr Morr Station, Kerry Muller, the Queensland National Parks and Wildlife Service, Keith Smith, the South Perth Zoo, Tom Smith, the Taronga Zoo, and Dr. and Mrs. Richard Wright. We also thank Jim Harris, Lisa Hartman, and Claire Mirande, who reviewed the manuscript and made many helpful suggestions.

METHODS

The senior author studied the ecology and behavior of these two species during the wet season and the dry season in order to predict the outcome of their sympatry. Brolgas were studied during September and October, 1972, near Kununurra, Western Australia, and at the Town Commons near Townsville, Queensland (Fig. 1). Eastern sarus cranes were observed in the Atherton Tableland of Queensland during November, 1972. September through November is the peak of the dry season in northern Australia. At this time the cranes congregate in flocks and do not breed.

From 13 January to 16 February 1984, both species were intensively studied in a region of sympatry near Normanton, Queensland. This period marked the onset of the wet season, and the cranes began to breed.

RESULTS

Cranes During The Dry Season

In northern Australia the dry season usually begins in April and ends in late November (Fig. 2). During the dry season both species of cranes congregate into flocks shortly after the chicks fledge during April and May. They do not disperse as pairs into the breeding areas until the next rainy season.

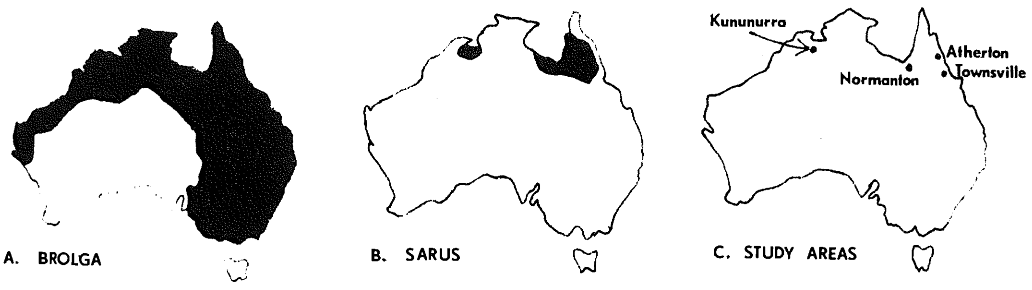

Fig. 1. Distribution of the brolga (A) and the sarus crane (B) in Australia (after Frith 1982); (C) locations where cranes were studied.

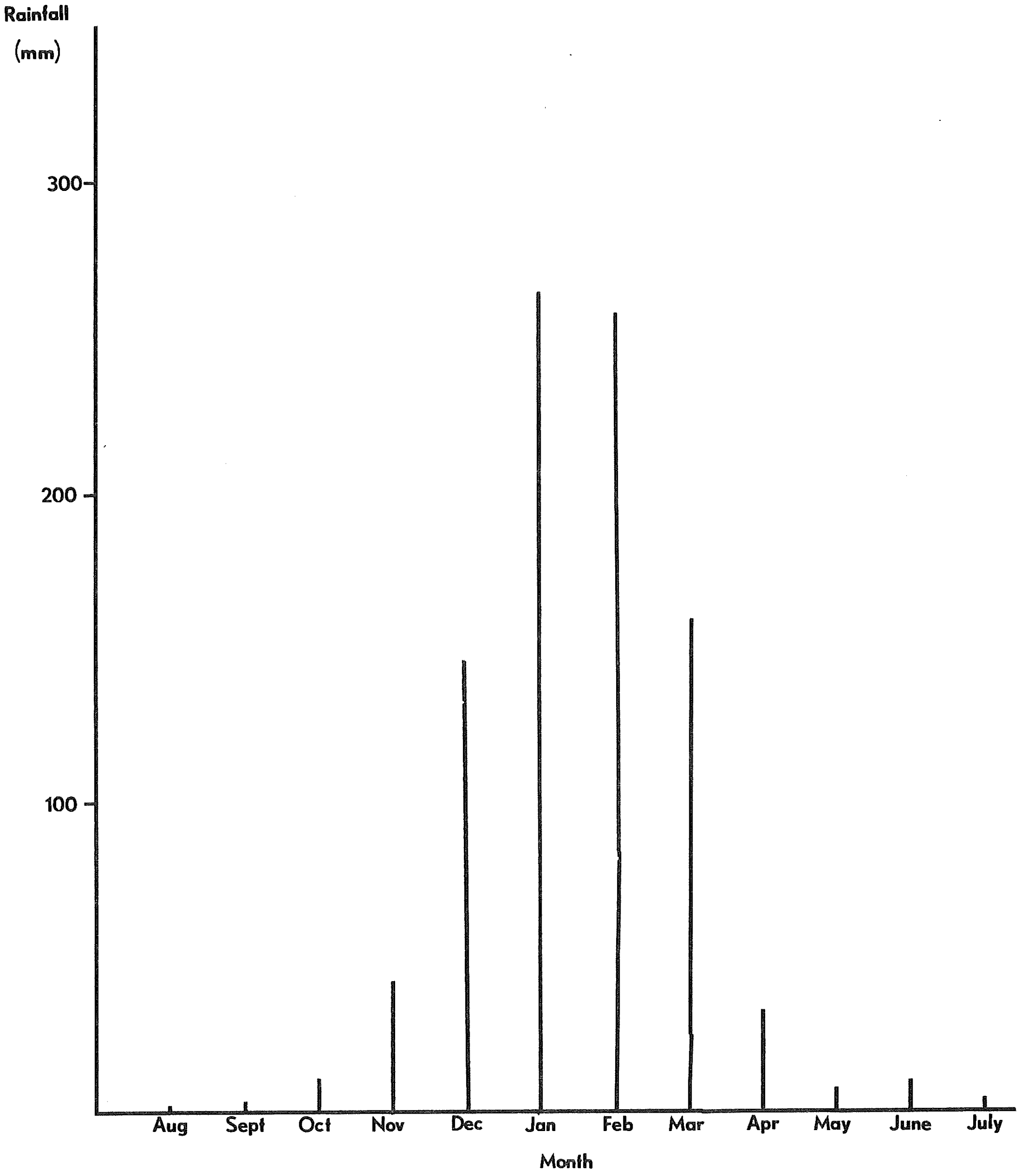

Fig. 2. Mean monthly rainfall at Normanton, Queensland, Australia.

Several thousand brolgas were observed near Kununurra in 1972. They roosted in shallow water on open sandy areas on the back side of a lake created by an irrigation dam. Early each morning they flew to sorghum fields where they fed in large flocks until mid-morning. They escaped the midday heat by either riding thermals to high altitudes for several hours or by bathing in lakes and streams. In mid-afternoon they moved back to sorghum fields to resume feeding. When feeding, they walked slowly with their heads down and grasped for sorghum seeds.

In contrast, the brolgas at the Town Commons near Townsville fed in dry coastal mudflats. Here they dug up and consumed tubers of the bulkuru sedge, the principal food of most brolgas during the dry season (Lavery and Blackman 1969).

Approximately 300 eastern sarus cranes in the Atherton Tableland, Queensland, roosted at night on the grassy tip of a narrow peninsula that juts into Lake Tinaroo. These cranes flew across the lake to newly plowed corn fields in early morning to feed on gleanings and rodents. Their foraging strategy was to walk slowly, search with heads down, and grasp for food items. At midday, most of the cranes gathered at several small ponds where they drank, bathed, and loated. In late afternoon they fed in fields again before returning to their roosts.

About 15 brolgas were also in this area. They did not roost or feed with the sarus, but they seemed to feed in a similar manner. Some of the birds in the sarus flocks appeared to be either F 1 or F 2 sarus X brolga hybirds (Archibald 1981).

Local people said that the cranes leave the Atherton Tableland at the beginning of the wet season and do not return until the following dry season.

The brolgas near Kununurra fed in a similar manner to the sarus and brolgas in the Atherton Tableland. However, the brolgas near Townsville fed in an entirely different niche from either of these populations.

Cranes During The Wet Season

From 13 to 16 January 1984, nonbreeding brolgas and sarus were seen near the town of Normanton, near the Gulf of Carpentaria, Queensland. From 17 January to 19 February, breeding pairs were studied within an 8 km radius of the Morr Morr Station headquarters, located 75 km northeast of Normanton (Fig. 3). January and February are typically the wettest months here, with mean monthly rainfalls of 265 mm and 257 mm, respectively, at Normanton (Fig. 2). The region experienced a particularly wet season during 1984, with 355 mm recorded in January at Morr Morr Station and an additional 207.5 mm during the first half of February.

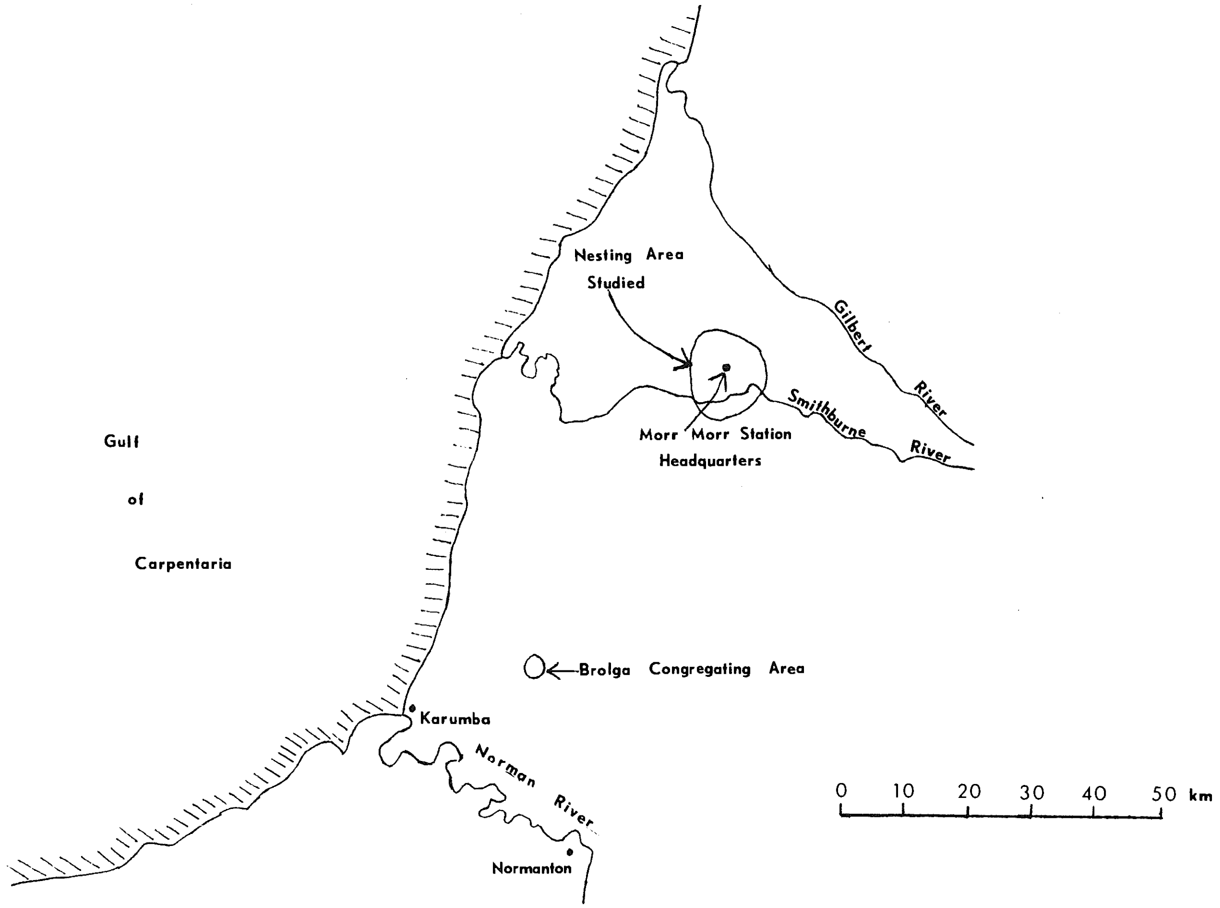

Fig. 3. The Normanton region, Queensland, 1984 study site.

More than 1000 brolgas were congregated in a shallowly flooded depression on the Karumba Plain, about 30 km north of Normanton, from 13 to 16 January. The emergent leaves of bulkuru sedges were starting to grow here, and the brolgas were digging up and consuming the sedge tubers. Chicks from the previous breeding season were not observed in this flock. Most of the cranes seemed to be paired. The frequent dancing and unison calling indicated that the birds were coming into breeding condition. Fourteen of the 135 unison calls recorded were from unmated females performing alone. They may have been soliciting mates. Perhaps new pairs form when the brolgas are in flocks just before dispersing to nesting territories.

Eastern sarus were rarely seen on the Karumba Plain, but they were abundant in the surrounding woodlands. Unlike the brolgas, the sarus were usually in isolated pairs at this time. Rather than digging for their food, they continually walked and grasped at food items in their paths.

As the wet season advanced, most of the brolgas left the bulkuru marsh and both they and the sarus established nesting territories. During 13 to 15 January several pairs of brolgas were consistently seen on the outskirts of Normanton in an area where Walkinshaw (1973) found sarus breeding in 1969. On 16 January two pairs of sarus were heard calling in that area, an indication that they were still breeding there.

At the Morr Morr Station, breeding pairs of brolgas and sarus, small groups of nonbreeders of each species, and single sarus seeking mates were scattered throughout the wetlands and uplands. By listening for unison calls, observing pairs, and finding their nests, 40 pairs of sarus and 35 pairs of brolgas were believed to be breeding within a 10 km radius of the station headquarters (Fig. 4).

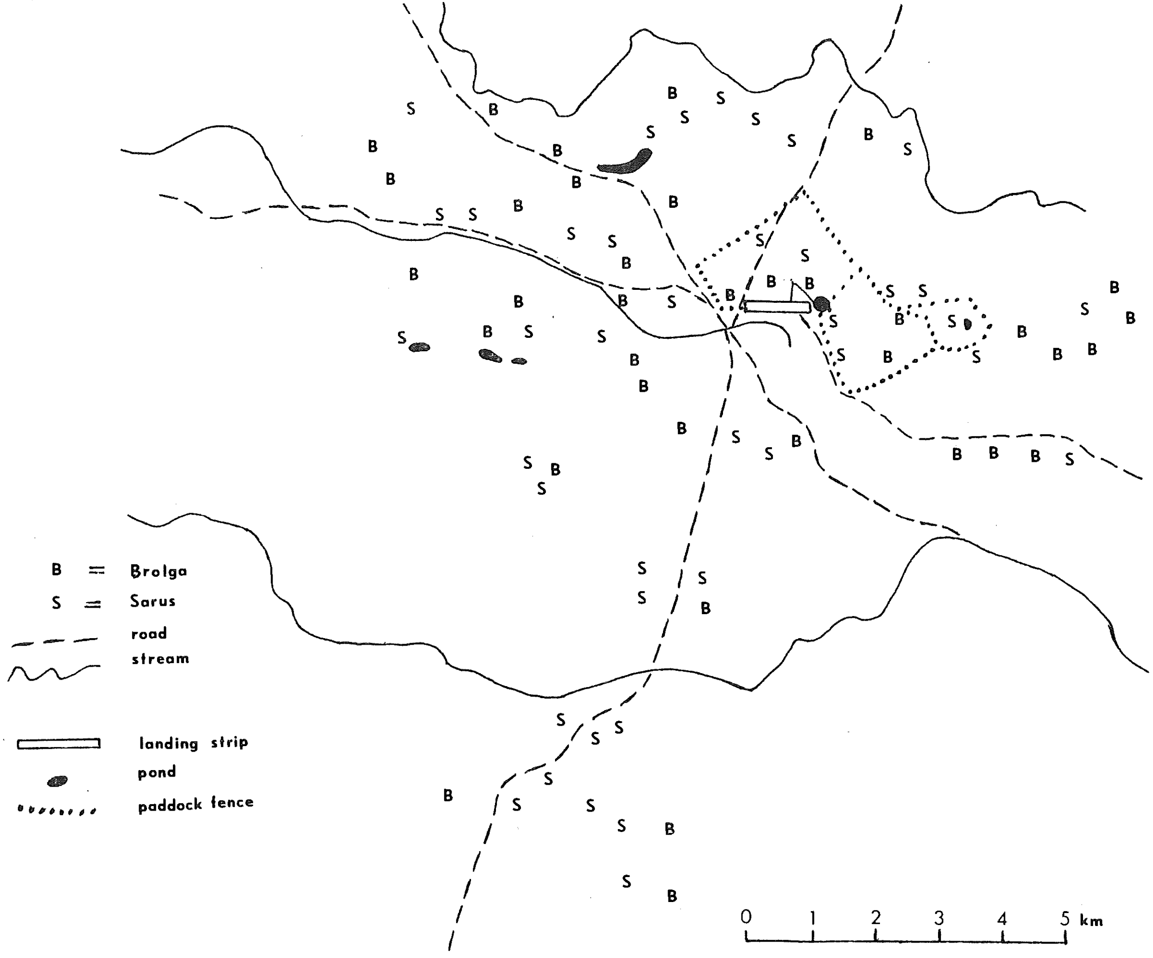

Fig. 4. Locations where nests of sarus and brolgas were found in the area around the Morr Morr Station headquarters.

The unison call is both a territorial threat and a sexual display. Mated pairs emit unison calls from their breeding territories in the early morning and late afternoon. The mean duration of 135 brolga unison calls recorded on the Karumba Plain was 11.3 male calls. In contrast, 118 unison calls given by pairs on their breeding territories lasted an average of 16.9 male calls. This difference is statistically significant ($p < 0.001$) and it may indicate an increased threat function of the display during the breeding season.

Both species placed their nests in close proximity to shallow wetlands of various types and sizes. They used three types of wetlands: the pond wetland, the ridge wetland, and the open wetland, plus wetlands that were intermediate to these classes.

The pond, the least common wetland, consisted of one to several ponds that were less than 0.5 m deep and only a few meters in length and width. These ponds invariably contained a yellow-flowered aquatic plant. The ponds were fringed with tall aquatic vegetation and were surrounded by dry uplands. Two sarus nests (5.9%) and one brolga nests (4.0%) were located beside such ponds.

The ridge wetlands were located between two slightly elevated, and often forested, ridges. They were 30 to 100 m wide but stretched for distances of up to several kilometers. These wetlands usually contained scattered trees, but not in as great a concentration as on the ridges. Nineteen sarus nests (55.9%) were found in ridge wetlands, while only six brolga nests (24.0%) were located in this habitat.

The open wetland was an expansive basin, often 1 to 2 km across, with shallow water and scattered boxwood trees. Only 4 sarus nests (11.8%) were placed in open wetlands, whereas 12 brolga nests (48.0%) were found there.

Intermediate wetlands were those that were transitional between ridge wetlands and open wetlands, where ridges bordered on open wetlands. Nine sarus nests (26.5%) and six brolga nests (24.0%) were found in intermediate wetlands.

In summary the sarus cranes preferred to nest in ridge wetlands and the brolgas favored open wetlands, but there was considerable overlap in the choice of nesting habitat. There was no difference in the plants sampled from around the nesting sites of the two species, with club rushes (<u>Scirpus</u> spp.), rice grass (<u>Heersia</u> spp.), and sedges (<u>Cyperus</u> spp.) being the principal plants (A. Haffenden 1985, pers. comm.).

Within these wetlands, the cranes nested directly beside the trunk of a tree (9 sarus nests--26.5%, 6 brolga nests--24.0%), within the shade of a tree when the sun was overhead (18 sarus nest--52.9%, 12 brolga nests--48.0%), or in the open away from shade (7 sarus nests--20.6%, 7 brolga nests 28.0%). The preference for shaded nesting sites by both species is an obvious benefit in this area where daytime temperatures soar above 40°C.

Nests were constructed at the beginning of the rainy season, when the wetlands were not yet filled with water. All of the sarus cranes nested in the water or, in pond wetlands, directly beside the water. In contrast, seven brolga nests (28.0%) were on dry ground a considerable distance from water at the onset of the rainy season but were later surrounded by water when the wetlands filled. Nesting on dry ground away from a wetland may be an adaptation that has evolved to minimize nest flooding. If so, the absence of this behavior in the sarus is evidence that it is a recent resident of Australia.

Among nests that were placed in the water, 16 sarus nests (47.1%) and 7 brolga nests (38.9%) were built on mounds elevated above the water. Eighteen sarus nests (52.9%) and 11 brolga nests (61.1%) were made entirely of piles of vegetation constructed into a platform in a level area of the wetland.

Table 1 compares the number of nests, the clutch size, nest failure, hatching rate, and survival of the chicks of the two species. Most of the eggs hatched in captivity, and the fledging rates are based entirely on chicks that were raised at ICF.

The hatching success, clutch size, and percentage of nests that contained eggs were similar in the two species. The sarus chicks at ICF had a much higher fledging rate than the brolgas (Table 1).

Interspecific Interactions

Subadult and/or nonbreeding individuals of both sarus (two to four) and brolgas (four to six) were regularly seen in the upland forests between Angoo Road and Lily Creek, near the Morr Morr Station. All of these cranes frequented the same area, but the two species were generally in separate flocks. Lone subadult brolgas and sarus were seen on three occasions, and twice a flock of three immature sarus and one sarus with mature head coloration was observed near the

Table 1. Comparison of the number of nests, clutch size, nest losses, hatching success, and fledging rates of sarus cranes and brolgas from Australia, 1984.

Category	Sarus		Brolga	
	N	%	N	%
Nests				
Total number	36		24	
With eggs	29	80.6	17	70.8
Without eggs	7	19.4	7	29.2
1 egg clutches	5	17.2	2	11.8
2 egg clutches	24	82.8	15	88.2
Mean clutch size	1.83		1.88	
Eggs				
Total number	53		32	
Known outcome	45		28	
Hatched	26[a]	57.8	16[a]	57.1
Lost	19	42.2	12	42.9
Chicks (at ICF)				
Hatched	19		11	
Half way to fledge	18	94.7	7	63.6
Fledged	17	89.5	4	36.4

[a] Most of the eggs hatched in captivity.

[b] Lost = Addled, death of embryo, flooded, or predated.

territory of a sarus pair. Once two immature sarus and one immature brolga were seen near the territory of a sarus pair.

On 1 February a flock of four immature sarus and six immature brolgas was seen. The sarus in the flock stood straight up, indicating their dominance over the brolgas, which adopted neck-retracted submissive postures. This flock broke up into single-species flocks shortly after it was first observed.

On 15 January an adult sarus and an adult brolga were seen foraging and walking together between Normanton and the Karumba Plain in an area where brolgas were seldom seen but where sarus were common. The two cranes behaved as a pair, although they did not unison call.

The brolgas were concentrated on the Karumba Plain before nesting, while the sarus were in the adjacent forests. Once a pair of sarus was seen foraging near a flock of more than 1000 brolgas in a salt pan on the Karumba Plain. The pair walked slowly, in typical sarus fashion, with heads down, and pecked at various food items. As they neared the flock they did not begin digging in the mud as the brolgas were doing. The sarus pair eventually flew back towards the woods without interacting with the brolgas.

Near the headquarters, territorial pairs of the two species were in close proximity to one another during the breeding season. There was overlap in the types of nesting habitat defended by the two species. When brolgas and sarus defended adjacent territories, each drove the other from its defended area and they answered one another's unison calls.

Interspecific unison call answering was more noticeable during the last half of the incubation period, suggesting that such a response may be learned through repeated proximal threats and combat. In contrast, the intraspecific response to unison calls is generally programmed, so pairs instinctively answer neighbors from the moment of initial auditory contact.

The brolga pairs unison called more intensely than the sarus during the breeding season. Although there were more pairs of sarus than brolgas, 118 brolga unison calls were recorded versus 71 for the sarus. The brolga unison calls lasted an average of 16.9 male calls, significantly longer than the sarus' 9.1 male calls ($p < 0.001$).

Species Strengths

The eastern sarus is larger than the brolga (Table 2). Although the culmen and tarsus measurements are similar, the sarus outweighs the brolga and is taller than the brolga (Blackman 1971, Archibald 1981). At ICF, male eastern sarus cranes have averaged 7.37 kg (N = 2) and male brolgas have averaged 7.36 kg (N = 4), while females of the two species averaged 5.84 kg (N = 3) and 6.15 kg (N = 1), respectively. The relatively higher weights of the captive brolgas may reflect their greater ability to put on fat in order to cope with the cooler Wisconsin climates. The brolga reaches temperate latitudes in Australia, while the sarus has historically been a tropical bird.

Sarus are usually several inches taller than brolgas and, in cranes, dominance is related to height. Dominant cranes assume upright stances and tend to tower over submissive ones, which adopt neck-lowered postures. In the subadult flock of four sarus and six brolgas mentioned earlier, the sarus assumed the upright posture and were dominant over the brolgas, thus giving the sarus an advantage from an early age.

The drive of a crane to defend its territory resulted in both intra- and inter-specific threats and attacks. Cranes usually return to the same territory each year and, perhaps for this reason, many brolga pairs were able to prevent the intrusions of sarus. On several occasions the researchers caused both sarus and brolgas to fly into the territroy of a neighboring pair of the other species. The intruders were invariably repulsed, regardless of which species was the defending pair and which was the intruder.

As previously mentioned, the brolgas unison called more intensely from their territories than did the sarus. This may indicate that the brolga must expend more energy than the sarus in order to hold its territory. This would imply that the sarus poses a greater threat to the brolga than the brolga does to the sarus.

The relationship between the two species on their breeding grounds seemed to be balanced, with an approximately equal number of pairs of sarus and brolgas. A critical factor concerns which species is the first to establish breeding territories at the beginning of the rainy season. Sarus prefer upland areas near the breeding grounds in the dry season. Such areas become breeding habitat during the wet season, which might give sarus cranes an advantage in securing breeding territories. Both species had mean laying dates of 22 January for the first egg and 24 January for the second egg. Fifteen brolga eggs had a mean hatching date of 1.4 days earlier than 27 sarus eggs (Fig. 5). The brolgas hatched their eggs earlier because their incubation period was 30 days, compared to 32 days for the sarus eggs.

The survivorship of the chicks, and thus the recruitment of new breeders into the population, is another parameter by which the two species can be compared. Of the 12 brolga eggs brought back to ICF, 11 hatched, but only 4 of the chicks were reared to fledging (Table 1). All 11 chicks were weak after hatching and required extensive care. Two chicks died within a few hours after hatching. Two others died within 5 days. One succumbed to lethal leg problems, and two died of diseases just before fledging. In contrast, of the 24 sarus eggs imported, 19

Table 2. Measurements of eastern sarus cranes and brolgas from Australia.

Species and sex	Mean weight (g)	N	Culmen (mm)	N	Tarsus (mm)	N	Source
Sarus males	8321	7	162.5	7	296.7	7	Walkinshaw 1973, Archibald 1981
Males	7370[a]	2	160.6[a]	3	305.3[a]	3	Archibald 1980, ICF records
Female	5840[a]	1	146[a]	1	282.5[a]	1	ICF records
Brolga males	6390	326	164.4	15	304.9	15	Blackman 1971, Archibald 1981, Johnsgard 1983
Males	7360[a]	4	158[a]	2	289[a]	2	ICF records
Females	5663	217	156.1	10	278.4	10	Blackman 1971, Johnsgard 1983
Female	6150[a]	1	141.5[a]	1	297.5[a]	1	ICF records

[a] Measurements were taken on captive birds.

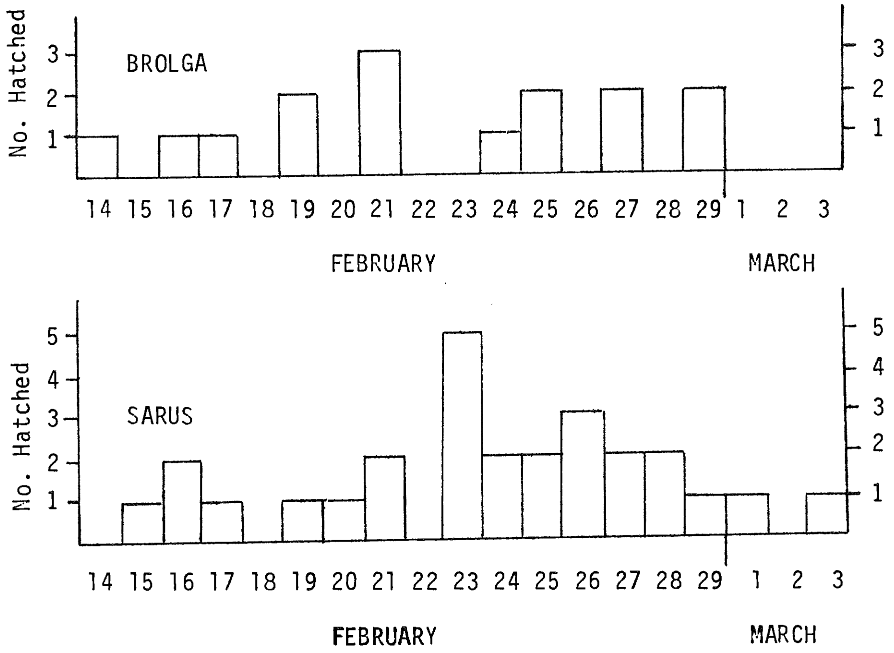

Fig. 5. Hatching dates of sarus and brolga eggs in 1984.

hatched and 17 of the chicks fledged. They ate on their own soon after hatching and gained weight much more quickly than the brolgas (Hesch, this proceedings). Australian researchers who had previously hand-reared many brolgas have also recognized the greater vitality of sarus chicks as compared to brolga chicks (A. Haffenden 1984, pers. comm.). The vitality of the sarus chicks may be largely responsible for the rapid increase in the sarus population in northern Australia.

The brolga is more tolerant of cold temperatures than is the sarus. Brolgas are found in southern Australia, where they must withstand freezing temperatures during the winter. The eastern sarus, which resides only in the northern part of Australia, has traditionally lived in the tropical climate of southeast Asia. At ICF, where winter temperatures are frequently below -10°C, the brolgas are more tolerant of the cold than the sarus are. This weakness may restrict the sarus to the warmer northern part of Australia, leaving the colder regions of the continent to the brolga.

The Normanton study area is not part of the brolga's traditional stronghold, which is the bulkuru country of northeastern Queensland (H. Lavery 1985 in lit), so the results may not be representative of the relationship of these species throughout their region of sympatry. The brolga is closely associated with the bulkuru sedge and has an advantage over the sarus in exploiting this food source.

The brolga has also had a longer time to adapt to the peculiarities of the northern Australia climate, and Australian water birds have a competitive advantage over invading species because of the rigorous selective pressures that they must face (Lavery 1985 in lit).

Possible Outcomes

When closely related species that were formerly allopatric suddenly become sympatric, there are several possible outcomes of the interaction. If they are competing for resources, as the brolga and sarus are, the outcomes may be 1) one species excludes the other (competitive exclusion); 2) one or both species may be excluded from part of the range of the other, but will survive in other areas; 3) one or both species will have depressed population densities, although neither is excluded from the area; 4) the two species will diverge in their niches to avoid competition (character displacement); or 5) one species may swamp the gene pool of the other (as in the example of the American black duck [Anas rubripes], whose gene pool is being swamped by the mallard [Anas platyrhynchos] in parts of its range).

The rapid increase in the sarus population, and the overlap in the choice of nesting sites in the two species, suggest that the sarus may be outcompeting the brolga during the breeding season. Because of the brolga's preference for open wetlands and the sarus' preference for forested wetlands, there may be selective pressures that will alter the genetic composition of each species (character displacement) so that they eventually avoid competition by adapting, respectively, to these different habitat types. However, if the sarus population increases rapidly enough, it may progressively move into the open marshes and displace the brolga.

During the dry season the two species occupy different niches and are concentrated in different locations. In Australia, the dry season is the limiting factor on populations of many animals that are restricted to aquatic habitats such as the coastal bulkuru marshes where the brolga feeds. In contrast, the sarus thrives in dry habitats during the dry season and only needs water for roosting and drinking. Therefore, the dry season may not be limiting the sarus population. The sarus might continue to expand its population until it fills the breeding habitat. If this happens, one would expect the brolga population to drop because its breeding space would be reduced. A final blow to the brolga would be the intrusion of sarus cranes into the coastal marshes during the dry season. The brolga is especially well adapted to eating bulkuru. It is not clear whether the sarus is likely to make more extensive use of bulkuru when its population becomes larger. The two species may partition the dry season food resources in order to avoid competition.

The rate of hybridization may well be insignificant to the outcome of this interaction. Hybrids have occurred in both the wild (Archibald 1981) and in captivity (Delocour 1935), but the number of wild hybrids is small. Archibald (1981) saw a probable backcross hybrid resulting from a sarus X brolga hybrid breeding with a sarus.

We believe that the sarus will probably become the dominant crane in northern Australia. The brolga will probably maintain its hold in southern Australia because it is more cold hardy than the sarus.

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PAIR FORMATION AND MATE FIDELITY IN SANDHILL CRANES

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Abstract: During a 4-year study of color-marked and radio-instrumented sandhill cranes in Florida, pair formation and duration was followed for 48 individuals. Cranes first began pairing during the latter part of their second year. Subadult pairings were generally ephemeral; the average subadult paired five times before successfully breeding. The migratory subspecies began breeding some 2 years earlier than the nonmigratory subspecies. Ultimately, pair bond duration was related to the production of young. Novice pairs that failed to produce young did not necessarily remain paired. Breeding males (4) that lost mates re-paired more quickly than females (2) in the same circumstance. On seven occasions females paired with males that had young from a previous pairing and helped raise their chicks.

PROCEEDINGS 1985 CRANE WORKSHOP

Cranes characteristically are perennially monogamous; "Once a crane pair is established they remain together for as long as both remain alive" (Walkinshaw 1973), but what constitutes an "established" pair? Although divorce in sandhill cranes (*Grus canadensis*) has been noted (Littlefield 1981), explanations were not evident. An understanding of pair formation and duration is essential to correctly assess reproductive potential and the consequences of mortality among the breeding segment of a population.

METHODS

During a 4-year study (1980-1984) of sandhill cranes on Paynes Prairie, Alachua County, Florida, we followed the initiation and duration of several pair bonds. Cranes have been banded and color-marked on Paynes Prairie since 1968, and the case history of individual birds is known for 10-15 years. Since 1977, 241 greater sandhill cranes (*G. c. tabida*), 122 Florida cranes (*G. c. pratensis*), and 259 birds of undetermined subspecies have been captured and individually color-marked. Approximately 80% of the resident population, and 15% of the migratory population that winters on the prairie have been color-marked. When banded, each bird was aged as juvenile, subadult, or adult. The age of each banded bird was identified by examining the stage of wing molt (see this Proceedings). Sex was determined subsequent to banding by observing unison calling postures (Walkinshaw 1949).

Selected adult (N = 18) and subadult (N = 4) Florida cranes were radio-instrumented and color-marked. These birds were monitored at least weekly for the 18-36 months that transmitters were operable. When a marked individual was observed, its social status was noted and, if associating with another bird, the potential mate was identified. A bird was considered "paired" if observed acting in concert with the same individual while feeding, loafing, roosting, or during agressive encounters at least twice not less than 1 week apart. Pairing is not always meant to imply a reproducing effort; many early pairings were more "associations" or "keeping company" (Richdale 1951) rather than efforts toward reproduction. On three occasions these first associations were among birds that were later found to be of the same sex (2 female-female, 1 male-male).

RESULTS AND DISCUSSION

Data from 48 cranes are considered here (Table 1): 10 banded as juveniles (first year), 6 as subadults (second year), and 32 as adults (birds 3 years or older). Juvenile cranes remained within the family group for most of their first year (10-11 months, N = 7) and then joined nonbreeder flocks.

Initial pairs or associations are formed within these nonbreeder flocks (Walkinshaw 1973). Similar associations occur in many deferred maturity species. Richdale (1951) found that a number of "flirtations" took place before a stable reproductive pairbond formed among

Table 1. Pairings among sandhill cranes banded in Florida.

Age during years of contact (age at banding)	No. of years of contact (banded but not frequently observed)	Age when first paired	Known mates
Adult	1	Unknown	A
Subadult	3	22 months	A+B
Subadult	1	18 months	A
Subadult	1	18 months	A
Adult	5	Unknown	A+B
Juvenile	2	24 months	A+B
Adult	1	Unknown	A
Adult	1	Unknown	A
Juvenile	3	24 months	A+B+C+D+F
Adult	1	Unknown	A
Adult	7(10)	Unknown	A
Juvenile	2	20 months	A+B+A+B+C
Juvenile	2	22 months	A
Adult	2	Unknown	A+B
Adult	2	Unknown	A+0[a]
Adult	1	Unknown	A
Adult	1	Unknown	A+0
Adult	2	Unknown	A+0
Adult	2	Unknown	A+B
Adult	2	Unknown	A
Adult	2	Unknown	A+0
Adult	1	Unknown	A
Adult	7	Unknown	A
Adult	3	Unknown	A
Adult	3	Unknown	A
Adult	3	Unknown	0+A
Adult	1	Unknown	A
Adult	2.50	Unknown	A+0+B+C+D+E+F
Juvenile	1.50	14 months	A+0
Adult	1	Unknown	A
Subadult	4	17 months	A+0+B+C
Subadult	5	Unknown	A+B+C
Adult	6	Unknown	A+B+C+D
Subadult	3.50	27 months	A+B+0+C+D+E+0+F
Adult	1	Unknown	A+0
Adult	1	Unknown	A
Juvenile	1	Unknown	0
Adult	11	Unknown	A
Adult	1.50	Unknown	A+B
Adult	0.75	Unknown	A+B
Adult	1.25	Unknown	A+B
Adult	0.50	Unknown	A
Juvenile	5.50	≥ 36 months	A+0+B+C+D+E+0+F+0
Adult (Juvenile)	2(11)	Unknown	A
Adult	0.75	Unknown	A
Adult	0.50	Unknown	A+B
Adult (Juvenile)	0.33(6)	Unknown	A+B+0
Adult	3.25(11)	≥ 24 months	A+B+C

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[a] 0 = unpaired

yellow-eyed penguins (*Megadyptes antipodes*). And in mute swans (*Cygnus olor*), Minton (1968) observed frequent mate changing before the first successful breeding. Nonbreeding swans had a 25% "divorce" rate, whereas breeding pairs had a 14% divorce rate. Sandhill cranes in this study went through many pairings before their first successful breeding. Average age of first pairing by 10 Florida sandhill cranes (Table 1) was 20.6 months (range 14-27 months).

As noted by Walkinshaw (1973), Kuyt (1981), and others, cranes can successfully reproduce late in their third year, but often do not succeed until their fourth or fifth year, or even later. Fortysix 3- to 5-year-old cranes were observed during this study (28 *G. c. tabida* and 18 *G. c. pratensis*). Five of 21 (24%) greater, and 0 of 14 Florida cranes succeeded in producing young that lived to leave the family unit or returned with their parents north in the spring before their fifth year (Table 2). There is the suggestion (chi-square $p \leq 0.10$) of a differential age of maturity between the two subspecies. A larger sample could clarify this question.

Many novice pairs of Florida cranes established and defended a territory, occasionally built nests, and laid eggs. These first attempts usually failed to produce young. Unsuccessful pairs did not necessarily stay together during the post breeding period. Of four pairs that incubated eggs but failed to fledge young, three pairs separated during the summer post breeding season. During this time (July-January), cranes (nonbreeders, failed breeders, and pairs with flight-age young) from a several square kilometer area may join together as a flock (Nesbitt et al. in press). This explains why pairings, in most instances, occurred among individuals that had associated previously. Example 12 in Table 1 is a juvenile male that paired with the same individual on two separate occasions before eventually pairing with a third bird.

Subadult associations were unstable, lasting sometimes only a few days or weeks. Twelve subadults averaged 1.21 associations per year, and 33 adults averaged 1.01 mates per year. Re-pairing among breeding adult Florida sandhill cranes usually occurred after the death or disappearance of a mate. Among 34 cranes banded during or after their third year, 47% had more than one mate (Table 1). A sex-related difference in the replacement interval following mate loss exists for the Australian raven (*Corvus coronoides*). Males found new females readily, often "within hours" of mate loss, but widowed females returned to the nonbreeder flock and there developed a new pair bond (Rowley 1983). On five occasions, re-pairing in Florida sandhill cranes followed the known death of a mate (Table 3) and once following disappearance of a mate. Four adult males, all with young, re-paired an average of 30.5 days following mate loss and succeeded in producing young. In contrast, an adult female (140) with two chicks did not pair again for 132 days after the death of her mate on 24 May 1983. She was unsuccessful in raising either of her chicks. Within 7 weeks of her mate's death she was with the nonbreeder flock, but did not pair for another 18 weeks. A second female (126) lost her mate when he disappeared between 23 and 26 January 1984. Her 10-month-old chick survived but she had not re-paired by 31 October 1984, 271 days after her mate's disappearance.

Table 2. Age of first successful breeding for sandhill cranes banded in Florida.

Age (yrs)	Subspecies	Number of cranes seen in fall	
		Without young (%)	With young (%)
3	Florida	9	0 (0)
4	Florida	5	0 (0)
5	Florida	2	2 (50)
3	Greater	13	4 (24)
4	Greater	3	1 (25)
5	Greater	4	3 (43)

Table 3. Re-pairing among adult Florida sandhill cranes following the death of a mate (all had young at time of mate's death).

Sex	Days before re-pairing	Time of year
Male	7	December
Male	33	Sept.-Oct.
Male	5	Dec.-Jan.
Male	≤ 77	Sept.-Nov.
Female	132	May-Oct.

Another re-pairing of interest involved adult male 106. This bird, its mate, and chick were trapped 1 September 1983. Apparently during trapping, the female's wing was broken and she subsequently died. On 4 October, 106 was paired with female 140. They remained paired and continued to raise 106's chick until 30 December when 140 became tangled in a barbed wire fence and died, in captivity, the next day. On 4 January 1984, 106 was associated with female 138. This association lasted only until sometime between 12 and 17 January 1984 when 138 was supplanted by another female.

A portion, perhaps the beginning of the replacement of 138, occurred during pre-roosting on 11 January. At 1614 hours the trio: 106, 138, and the chick flew to the roost area. The pair unison called and all three began driving an unpaired female, 65870713, from the area with Directed-walk-threats and Guard Calls (Nesbitt and Archibald 1981). The pair continued to unison call and began dancing. Pre-copulatory Bill-raising (Masatomi and Kitagawa 1975) was briefly given by 138. The intruding female (65870713) remained within 100 yards of the trio throughout this time. As 1745, the intruding female began circling the trio giving Directed-walk-threats. As 106 left the company of 138 and the chick and approached the intruding female, presumably to drive her away, she gave pre-copulatory Bill-raising, crouched, and raised her tail. She attempted to unison call with 106; he did not respond, and the intruding female was then driven off by 138. By 17 January 1984 the intruding female was paired with 106. They successfully fledged the chick and attempted to nest during the 1984 season but the eggs were infertile. Female 138 did not successfully nest during 1984 but was paired by mid-August.

In long-lived, delayed maturity species it is advantageous for individuals to breed with their former mates (Emlen and Oring 1977). It is reasonable to assume that because of their high degree of parental investment, selection is an important part of mate choice (Parker 1983). Pair formation in whooping cranes (<u>G. americana</u>), for example, follows a long-term familiarization that may extend over 2-3 seasons (Bishop 1984). The fact that many initial bonds are of short duration suggests that individuals are "selecting" a mate from among several potentials.

Cranes, like some other deferred maturity species, may be biologically capable of breeding before ecological criteria are met. Brown pelicans (<u>Pelecanus occidentalis</u>) usually do not begin breeding until they develop adult plumage at age 4 or 5 years (Schreiber and Schreiber 1983). In new or expanding populations or under unusual circumstances (Williams and Joanen 1974, Nesbitt et al. 1980, McNease et al. in press) where nesting habitat is not limited, or there are few established breeders, brown pelicans will breed when 2 and 3 years old. The Great Lakes population of greater sandhill cranes, from which the birds that winter on Paynes Prairie derive (Nesbitt and Williams 1979), has expanded from about 1,600 birds in 1944 (Walkinshaw 1949) to at least 15,000 in 1980 (Lovvorn and Kirkpatrick 1981). The Florida sandhill population on Paynes Prairie has remained at 80-100 birds since 1968. Range-wide the population has been described as static or slowly declining (Williams 1978). The observed difference in age of first successful reproduction between the greater and the Florida subspecies may be related to differences in resource competition and mate availability.

Neophyte breeders that did not succeed in producing young, and even those that did produce young but lost them sometime before fledging, did not necessarily remain paired. As these pairs went through the gregarious, nonbreeding period, the pair bond was as likely to break down as remain intact. During this study, three of four pairs of neophyte breeders separated after they failed to fledge young. The presence of young enforced the pair bond until the young departed from the family group. The departure of juveniles coincides with the onset of breeding, consequently, it is unlikely that successful pair members would then select new mates. With the synchrony that results in a successful reproductive history over several years, a pair could perhaps go for 3 or 4 years without producing young yet remain paired. But a novice pair that was unproductive often separated. Separation of unproductive pairs had definite survival value to the individual by ensuring that a bird would not invest time and energy in maintaining a bond that might never be productive. It may, in fact, be a most economical way for a bird to go through the complex process of finding a compatible reproductive partner.

At least among the nonmigratory subspecies, the breeding male seems to be the critical individual. The comparative ease with which breeding males re-paired following loss of a mate provides insight into the dynamics of pair formation. Males, following mate's death, continued to maintain the territory, usually attracted another female, and successfully fledged their young. In contrast, singled females were unable to maintain the territory and fledge the chick but returned to the status of a nonbreeder to develop a new pair bond. In seven instances, females joined a solo male and helped raise a chick to which she was genetically unrelated. The ultimate advantage of this tactic to that female may outweigh the disadvantage of providing parental care to an unrelated chick because, if successful, this female would most certainly remain paired and breed with this territorial male during the next breeding season.

CONCLUSION

An established pair of sandhill cranes consists of a male and female that share a successful reproductive history. They have each previously associated with between 3.6 and 6.0 potential mates. It has taken them at least 3 to 5 years to begin breeding, but once established the pair may remain together for 10 or more years. Singled adult male Florida cranes are capable of holding territories and raising young after the loss of their mate; females apparently are less capable of doing so. This apparent disparity between the responses of males or females to the loss of a breeding partner may be a consequence of a low sample size or a function of the limited number of available breeding territories in the studied population. Drewien (pers. comm.) found no such sex related disparity in the greater sandhill crane population at Gray's Lake, Idaho. Females will pair with singled adult males that have young by another mate, consequently, it should not always be assumed that a juvenile is being raised by both genetic parents.

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AN OUTBREAK OF EASTERN EQUINE ENCEPHALITIS VIRUS IN CAPTIVE WHOOPING CRANES

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Abstract: Eastern equine encephalitis (EEE) virus is an arbovirus that infects a wide variety of indigenous bird species, although mortality is generally restricted to introduced birds, such as pheasants, pigeons, house sparrows, and chukar partridges. The principal vector for the virus is the mosquito *Culiseta melanura* which breeds in swampy areas and primarily attacks birds. Seven of 39 whooping cranes (*Grus americana*) at the Patuxent Wildlife Research Center (PWRC) died between September and November, 1984. Four birds were found dead without any clinical signs, and three showed signs of lethargy, ataxia, and neck and leg paresis before death. Complete post-mortem examinations were performed on all birds. The only significant gross lesions were an accumulation of clear yellow fluid in the anterior abdominal air sacs of three birds and an enlargement of the liver of four others. Bacterial and chlamydial cultures produced no significant growth. Results of extensive toxicological analyses were negative. Histopathologic examinations showed a diffuse inflammatory response with necrosis throughout many organs with no inclusion bodies evident. EEE virus was isolated from tissues from embryonated egg inoculations and tissue culture and confirmed by five independent laboratories. Fourteen (44%) of the 32 surviving whooping cranes had antibodies to EEE in their serum. Research and measures to control EEE at PWRC have been initiated.

PROCEEDINGS 1985 CRANE WORKSHOP

Eastern equine encephalitis (EEE) virus is a mosquito-borne virus (genus *Alphavirus*, family Togaviridae) found primarily in the eastern and northcentral United States and adjacent areas of Canada, in parts of Central and South America, and in the Caribbean (Monath 1979). The natural occurrence of this arbovirus in birds was first demonstrated in pigeons (Fothergill and Dingle 1938) and ring-necked pheasants (Tyzzer et al. 1938). Infections in birds are usually subclinical and have been reported in many indigenous species. A review by Stamm (1963) listed 51 species of wild birds in which infections have been detected or experimentally induced. Fatal infections commonly occur in introduced species such as pheasants, pigeons, house sparrows, and chukar partridges. In Maryland, EEE virus has been identified in pheasants, house sparrows (Byrne et al. 1961), and pen-raised chukar partridges (Moulthrop and Gordy 1960).

EEE virus is transmitted in nature by several species of mosquitoes, with epizootics occurring typically in the late summer and fall. The principal biological vector among birds is *Culiseta melanura* (Diptera: Culicidae). This mosquito is associated with freshwater swamps and exhibits a strong feeding preference for bird blood (Nasci and Edman 1981). Enzootic foci of EEE virus are generally in or adjacent to *C. melanura* breeding habitat (Moussa et al. 1966). After a viremic bloodmeal and following an appropriate incubation period, this mosquito can transmit EEE virus for life (Coleman and Kissling 1972). Transmission among flocks of penned birds, such as pheasants, may occur through cannibalism (Beaudette et al. 1952). In some circumstances, this arbovirus can be transmitted mechanically by biting insects if their mouth parts are contaminated (Coleman and Kissling 1972).

Susceptible birds may circulate EEE virus in high titers for several days without evidence of infection (Kissling et al. 1954). These species are epizootically important because they are a source of infected blood for potential vectors (Lord and Calisher 1970), yet the infected birds remain mobile and may transport the virus long distances. Small passerines tend to have higher concentrations of virus in their blood than larger birds and, thus, are potentially the more important vertebrate hosts for mosquito infection (Coleman and Kissling 1972). Although known for some arboviruses, the overwintering mechanism for EEE has not been established.

Clinical signs of EEE viral infections in birds may vary from inapparent to acute death. In cases where the virus successfully invades the central nervous system (CNS), affected birds become depressed, lethargic, uncoordinated, paralyzed, and assume abnormal postures, especially of the head and neck (Karstad 1971). Kissling et al. (1954) reported EEE viral infections in birds are primarily found in the liver rather than the CNS.

Diagnosis is usually made by isolating the virus in embryonated chicken eggs, suckling mice, or appropriate tissue culture systems because there are no gross lesions pathognomonic for this disease and clinical signs are usually nonexistent or similar to other avian diseases. Specific identification is usually accomplished by neutralization tests, incorporating antisera to suspected arboviruses.

This paper describes an outbreak of EEE virus in whooping cranes at PWRC in 1984 and outlines current plans for prevention of future EEE epizootics in captive cranes.

We are grateful to the following individuals for their technical assistance, advice, and cooperation throughout various phases of this study: D. Docherty, C. Franson, L. Locke, and R. Stroud, National Wildlife Health Laboratory, U. S. Fish and Wildlife Service, Madison, WI; C. J. Peters, C. L. Bailey, D. M. Watts, and C. L. Crabbs, U. S. Army Medical Research Institute of Infectious Diseases, Ft. Detrick, MD; B. Francie and T. Tsai, Center for Disease Control, Ft. Collins, CO; J. Dorothy, S. Joseph, C. McComb, and G. Stein, Maryland Department of Agriculture, MD; H. Nelson, J. Pierson, and D. Seene, National Veterinary Service Laboratory, USDA, Ames, IA; M. Bush and R. Montali, National Zoological Park, Washington, DC; G. Gee and B. Rattner, PWRC, Laurel, MD; T. Scott, University of Maryland, College Park, MD; and A. J. Main, Yale University School of Medicine, New Haven, CT.

CASE HISTORY

The Endangered Species Research Program at PWRC was established in 1965 by the U. S. Fish and Wildlife Service. It includes a captive breeding program that is designed to give special attention to severely threatened or declining species whose future could not be assured by existing protection and management methods (Erickson 1968). Whooping cranes have received the most public and scientific attention among the species at PWRC which have been successfully propagated and reintroduced to the wild.

Seven of 39 captive whooping cranes at PWRC during the summer of 1984 died between 17 September and 4 November (Table 1). EEE virus was recovered from five of these birds. This event was unprecedented at PWRC, and it was notable by the acute nature of the disease. In contrast, clinical signs and mortality were not observed in 248 sandhill cranes (<u>Grus canadensis</u>) in pens interspersed among the whooping crane pens.

Table 1. Summary of whooping crane mortality caused by eastern equine encephalitis virus at the Patuxent Wildlife Research Center, Laurel, Maryland, 1984.

Bird	Date of death	Age in yrs/ sex	Egg origin[a]	Location at PWRC[b]	Comments
1	17 Sept	3/F	PWRC	UFP A-1	Dead in pen
2	24 Sept	1/M	WBNP	LFP 4	Dead in pen
3	26 Sept	5/F	PWRC	UFP A-4	Dead in pen
4	25 Oct	16/F	WBNP	URP	Dead in pen
5	28 Oct	2/F	PWRC	LFP 6	Hospitalized 5 hrs before death
6	3 Nov	6/M	PWRC	UFP B-1	Hospitalized 3 hrs before death
7	4 Nov	2/F	PWRC	LFP 6	Hospitalized 8 hrs before death

[a] PWRC = Patuxent Wildlife Research Center, Maryland, USA; WBNP = Wood Buffalo National Park, Northwest Territories, Canada.

[b] LFP = Lower flight pen; UFP = Upper flight pen; URP = Upper right pen

METHODS AND MATERIALS

Emergency medical treatment was provided for three whooping cranes which were observed with signs of lethargy, ataxia, and paresis of the neck and legs. Treatment involved hospitalization and supportive therapy. It included intravenous and subcutaneous administration of fluids, supplemental heat, and injections of vitamins, steroids, and antibiotics. Complete blood counts, serum chemistries, and fecal examinations were also performed.

Postmortem examinations were conducted on the dead whooping cranes. Tissue samples were aseptically collected from each carcass and processed for histopathology. Sections of liver and kidney were evaluated after Gram and Giemsa staining. Heart blood, ascitic fluid, liver, lung, spleen, and intestines were cultured for bacteria on blood and MacConkey's agar and in Schaedler's broth. Isolation of chlamydial organisms was also attempted. Cytological and parasitological examinations were made. Portions of brain, lung, liver, spleen, kidney, and alimentary tract were frozen at -70°C and later assayed for virus on Vero cell monolayers or in embryonated chicken eggs. Electron microscopic examination was conducted on a viral isolate. Samples of brain, liver, lung, and kidney tissues and gizzard contents were frozen and submitted for detection of selected heavy metals, pesticides, and biotoxins. Feed samples were analyzed for nutrient content and potential toxicants.

After the etiological agent was identified, ground and air reconnaisance was conducted at PWRC and adjacent areas to determine the presence and distribution of the principal vector C. melanura. Standard mosquito dippers were used to collect larvae and Army miniature solid state light traps and 0.028-cubic meter resting boxes were used to collect adult mosquitoes. Surviving captive cranes, raptors, and wild birds were bled via the jugular or brachial vein. Serum from clotted blood was separated and assayed for N antibody to EEE virus by plaque reduction neutralization in Vero cells.

RESULTS

Hematological data from one of the three cranes sampled antemortem revealed an anemia and a depressed total white blood cell count. Selected serum chemistries (aspartate amino transferase [SGOT], lactate dehydrogenase [LDH], and uric acid [UA]) in these birds were greatly elevated, indicating liver and kidney damage. Fecal analyses were negative for intestinal parasite eggs and coccidia.

Postmortem examination of the whooping cranes revealed that all seven birds were in good physical condition. The only significant gross lesion noted in the first three cases was an accumulation of clear yellow fluid in the anterior abdominal air sacs. In subsequent cases, hepatomegaly and dark reddish to purple areas were observed in the intestines. Other organ systems were not remarkable. Bacterial and chlamydial cultures produced no significant growth. All samples were negative for significant levels of heavy metals, pesticides, and biotoxins for which they were assayed. Nutrient content of the feed was within normal limits.

Microscopic examination revealed a diffuse inflammatory response, characterized by macrophages, with necrosis throughout many tissues. These changes were indicative of a virulent systemic pathogen, possibly of viral etiology, although no inclusion bodies were evident. Special liver and kidney stains revealed no bacteria and chlamydia.

The agent isolated was identified as a member of the family Togaviridae by electron microscopic examination and as EEE virus by complement fixation assay. The presence of EEE virus antibody was confirmed independently by five different laboratories. Among the surviving whooping cranes, 14 (44%) of 32 as well as 13 (34%) of 38 examined sandhill cranes contained N antibody to EEE virus.

During the field surveys, several overwintering C. melanura larvae were collected approximately 1.5 km northwest of PWRC. Probably because the surveys were initiated after several hard frosts had occurred in early November, no adult C. melanura were found.

DISCUSSION

The crane propagation and reintroduction program at PWRC currently houses 33 whooping cranes (approximately 11 females, 22 males), 26 Mississippi (G. c. pulla), 77 greater (G. c. tabida), 132 Florida sandhill cranes (G. c. pratensis), and 1 greater sandhill whooping crane hybrid. Losses of whooping cranes to EEE virus was a serious setback for the captive breeding program because five of the seven deaths were females, including one from a breeding pair. This disease outbreak has far-reaching implications for the recovery effort because whooping cranes appear to be extremely susceptibile to EEE virus. Therefore, the potential adverse impact of this pathogen must be an important consideration when selecting sites to establish other wild whooping crane flocks.

EEE virus infects birds naturally in a sylvan cycle; it occurs sporadically and somewhat unpredictably in the eastern United States. The mosquito vector breeds in heavily-shaded seepage areas (i. e., in root holes under fallen trees) associated with freshwater swamps. Although habitat at PWRC does not appear suitable for C. melanura, one breeding site was found in an adjacent area, and biological control measures will be implemented. Aerial and ground reconnaissance studies are underway to identify other potential breeding sites. C. melanura larvae have been collected from 10 counties in Maryland, primarily in or near the extensive wooded swampland that borders the major river systems on the Eastern Shore. The collection sites were generally less than 3 m across, with some of the sites less than 100 sq cm in size. EEE virus has been repeatedly isolated from C. melanura collected in the Pocomoke Cypress Swamp (PCS) southwest of Pocomoke City, Maryland (Williams et al. 1974, Muul et al. 1975). Much of the available knowledge about C. melanura originated at the PCS (Joseph and Bickley 1969).

Birds that survive an EEE viral infection become immune. Among the whooping cranes currently housed at PWRC 14 of 32 were infected with EEE virus and have developed antibody titers. Theretore, the identification or development of an effective vaccine for whooping cranes should minimize the risk of tuture disease in these captive birds. Research and surveillance measures designed to prevent future EEE virus transmission at PWRC include: (1) Evaluation of an inactivated human EEE virus vaccine for providing immunity and protection to whooping cranes. (2) Continuation of the C. melanura surveillance program to define its breeding sites, geographical and seasonal distribution, and population density in and around PWRC. A program to control C. melanura larvae will be initiated based on these results. (3) Serological monitoring of captive cranes and sentinel birds for antibody titers to identify evidence of EEE virus transmission. Evidence of local transmission and large numbers of female C. melanura may necessitate an adult mosquito control program.

The epizootic briefly described in this report represents the most significant loss of whooping cranes ever experienced at PWRC. With identification of the etiological agent, use of an EEE virus vaccine, arbovirus surveillance, and vector control measures, we anticipate that normal whooping crane propagation activities at PWRC can be safely resumed and progress normally.

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MORTALITY OF CRANES AND WATERFOWL FROM POWERLINE COLLISIONS IN THE SAN LUIS VALLEY, COLORADO

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Abstract: Crane and waterfowl mortality from collisions with powerlines in the San Luis Valley, Colorado, was investigated during two spring and two fall periods of 1983-84. Powerline segments were searched for dead birds and cranes were observed as they flew over the lines. Factors contributing to the incidence of powerline strikes were analyzed. Sandhill cranes (*Grus canadensis tabida*), and particularly whooping cranes (*G. americana*), were more vulnerable to wire strikes than waterfowl. Juvenile cranes struck powerlines more frequently than adults ($p=0.001$). The incidence of collisions was influenced by the proximity of powerlines to roosting and feeding sites and by adverse weather conditions (fog, precipitation, and wind) which affected visibility and flight control ($p=0.001$). Evaluation of experimental modification of a 115 kv transmission line indicated that static wire removal substantially reduced strikes; however, in a limited study, static wire enlargement was not shown to reduce strikes. We recommend locating new powerlines at least 2.0 km from traditional roost and feeding sites, and investigating techniques of color marking static wires to increase visibility and minimize collisions at perennial problem locations.

1985 CRANE WORKSHOP PROCEEDINGS

The San Luis Valley in south-central Colorado is the major spring and fall migration stop for the Rocky Mountain populations of greater sandhill cranes and cross-fostered whooping cranes (Drewien and Bizeau 1974, 1978, Kauffeld 1981). These populations currently number 17,000-20,000 sandhill cranes and 30-35 whooping cranes. Cranes use the valley for 3-4 months annually, primarily from October through mid-November and mid-February through mid-April. The valley also provides important habitat for 8,000-10,000 Canada geese (*Branta canadensis*) and over 25,000 other waterfowl (M. Suthers, pers. comm.).

Barley, wheat, and potato farming are the primary land uses in the valley, and additional lands are converted annually to agriculture. Recently, several large power transmission lines and numerous distribution lines have been constructed to service the expansion of overhead sprinkler irrigation. Many power lines cross traditional crane and waterfowl concentration areas.

It is well established that powerline collisions are a source of avian mortality (Walkinshaw 1956, Cornwell and Hochbaum 1971, Drewien 1973, Krapu 1974, Stout and Cornwell 1976, Anderson 1978, Tacha et al. 1978, Malcom 1982, Brown et al. 1984). The potential effect of collision mortality on populations of rare and endangered species has been noted by Lee (1978), Thompson (1978), and Faanes (1983, Assessment of powerline siting in relation to bird strikes in the Northern Great Plains, Unpubl. Rept., Northern Prairie Wildl. Res. Cent., Jamestown, North Dakota. 90 pp). Since 1956, six powerline collisions resulting in injury or death of whooping cranes have been documented in the Wood Buffalo-Aransas population (J. Lewis 1985, Whooping crane mortality/injuries. Unpubl. Table. U. S. Fish and Wildlife Service, Albuquerque, N. M.). A minimum of eight cross-fostered whooping cranes in the Rocky Mountain population have struck powerlines since 1977. Seven of these were killed or incapacitated accounting for 39% of all known losses of fledged birds to date (unpubl. data, Id. Coop. Wildl. Res. Unit). Six of these line strikes occurred in the San Luis Valley.

This study was initiated to assess crane and waterfowl mortality from powerline collisions in the San Luis Valley, to evaluate factors which contribute to collisions, and to provide insight on how to reduce that mortality.

We thank G. Halvorson, U. S. Fish and Wildlife Service, Albuquerque, for obtaining funds and assisting with project initiation for fall 1983 studies. D. Walker substantially contributed to data collection and summary during fall 1983, and D. Kingery generally donated her time walking powerlines throughout the study. We especially appreciate the assistance, facilities, and equipment made available by M. Nail and staff of Alamosa-Monte Vista National Wildlife Refuge. We are grateful to San Luis Valley Rural Electric Cooperative, Inc., Public Service Company of Colorado, and Colorado Ute Electric Association, Inc. for their cooperation in modifying a transmission line and providing technical information. K. Reese assisted with statistical analysis, and helpful reviews of the manuscript were provided by S. Derrickson, and C. Rice. E. Myers typed the manuscript.

METHODS

Mortality Surveys

Powerline collision (strike) mortality data were collected during two spring (February-April) and two fall (October-November) periods 1983-84. Selected segments of electric transmission (69 and 155 kv) and distribution (7.2-24 kv) lines were thoroughly searched one or more times each season (Fig. 1). Weekly searches of 14 transects along 10 different powerlines were conducted during fall 1983. Supplemental information on strike mortality was provided by Alamosa-Monte Vista National Wildlife Refuge personnel.

The area searched under all lines included an adjoining strip approximately 30 m on each side of support poles. One or two observers walked a zig-zag pattern, or when terrain offered good visibility, an all terrain cycle or truck was used.

All dead birds, or parts thereof, found within the search area were considered strikes, including feather spots indicating a bird had hit the ground and left the area. For subsequent identification, all avian carcasses were marked with red enamel paint and numbered strips of orange flagging tape. Species, age, sex, type of injuries, carcass condition, and date of death were recorded when possible. Strike locations were plotted on maps and the surrounding habitat, approximate distance from roost and feeding sites, and recent weather conditions were noted.

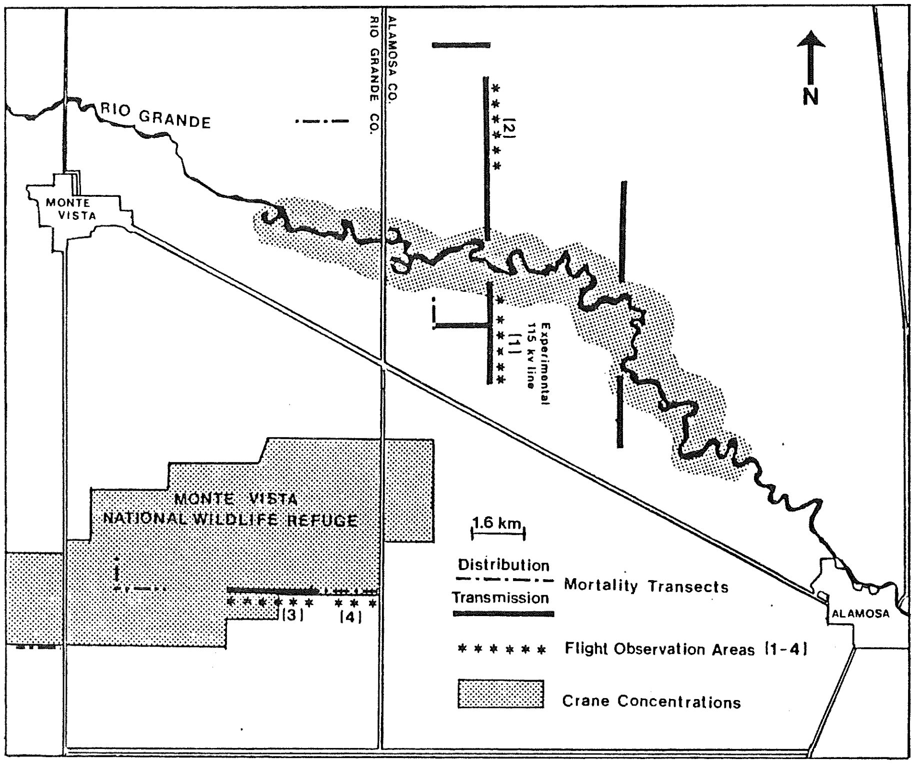

Fig. 1. Locations of major powerline transects for bird mortality surveys (two spring and two fall periods 1983-84) and bird flight observation areas (fall 1983) in the San Luis Valley, Colorado.

Experimental Modification of a 115 kv Transmission Line

A 3.2 km segment of 115 kv transmission line (Fig. 1) was experimentally modified and monitored through a cooperative effort by Colorado Ute Electric Association, Inc. (CUEA), the U. S. Fish and Wildlife Service (FWS), and Edison Electric Institute (EEI). We began intensive surveys of this line in March 1983, after a whooping crane with impact injuries was found nearby.

In an effort to reduce crane strikes, the static wire was experimentally removed in August 1983. The static wire is the nonconducting, topmost wire on a powerline used to minimize power outages from lightening strikes. It is normally smaller than the conductor, and appears to be the wire most often struck by birds in flight (Thompson 1978, Faanes 1983 loc. cit.).

In October, CUEA and FWS initiated thrice-weekly searches of the experimental segment for dead birds, and their effort continued throughout fall 1983 and spring 1984 (H. G. Laire. 1984, San Luis Valley - Waverly 115 kv transmission line - 1983, Unpubl. Rept., Colorado Ute Electric Association, Montrose). Their mortality data for these two periods are included in this paper.

In September 1984, cooperators with EEI experimentally replaced two spans (ca. 560 m) of static wire with standard 0.95-cm diameter wire, and two spans with 2.54-cm diameter self-damping wire to determine if the larger wire would be more visible to flying birds and thereby reduce collision frequency. The remaining nine spans were left without static wire. Using remote cameras, EEI contractors filmed crane flights over six experimental spans (T. Nelson, pers. comm.). We continued searches of the entire segment for dead birds.

Bird Flight Observations

Bird flight observations were made at four locations from 8 October-12 November 1983 (Fig. 1). Area 1 comprised a segment of the experimental 115 kv transmission line without static wire. It was situated immediately adjacent to and between heavily-used roost and feeding sites. Area 2 transected cropland feeding areas north of the Rio Grande River and represented a segment of the experimental transmission line with static wire intact. Areas 3 and 4 represented typical segments of 69 kv transmission and 7.2 kv distribution lines, respectively. Both separated a nearby roost on Monte Vista Refuge from feeding sites 3 km or more away.

Observations were made from vehicles, primarily at sunrise and sunset when large numbers of birds were moving to and from roosts. We attempted to gain supplemental observations when large groups of birds were flushed (wild flush) and during adverse weather.

During all observations the species, flock size, reaction distance, altitude above line, flight direction, and weather conditions were recorded for each flight. A flight was defined as a flock of birds, moving together without any break in the unit.

Data Analysis

Daily weather data were compiled from National Weather Service records in Alamosa. Wind speed, fog, and precipitation were considered potentially important to strikes due to their adverse effects on flight maneuverability and visibility. For the purposes of our analysis, weather for each day of the study period was classified as fair or foul. A foul weather day was one having fog, rain, snow, or wind exceeding an average of 32 km/hr for a 3 hour period.

The relationship between weather and bird strikes was determined using a Chi-square contingency table (Zar 1974). The proportion of fresh bird strikes found on foul weather days was compared to the proportion of foul weather days in the survey period. Chi-square analysis was also used to compare the proportion of juvenile sandhill crane strikes found with the proportion of juveniles in the population.

RESULTS

Mortality Surveys

During spring and fall 1983-84, 115 dead birds were found. Sandhill cranes were the most frequent mortalities (67.8%), followed by ducks (17.4%), Canada geese (7.0%), and whooping cranes (2.6%). Five other species (5.2%) were recorded (Table 1).

Table 1. Powerline strike mortality in the San Luis Valley, Colorado during spring and fall crane use periods 1983-84.

			Species					
Season and line type	No. lines surveyed	Distance (km)	Whooping crane	Sandhill crane	Canada geese	Ducks[a]	Other[b]	Total birds
Spring 1983								
Transmission	2	8.8	1	18	4	5	1	29
Distribution	2	2.4	0	5	1	4	1	11
Fall 1983								
Transmission	4	16.2	0	9	1	1	0	11
Distribution	6	6.0	0	3	0	0	0	3
Spring 1984								
Transmission	3	5.1	1	7	0	3	1	12
Distribution	12	4.8	1	15	0	0	2	18
Fall 1984								
Transmission	1	3.2	0	13	1	4	0	18
Distribution	2	3.2	0	8	1	3	1	13
Total			3	78	8	20	6	115

[a] Eleven mallards (<u>Anas platyrynchos</u>), 2 blue-winged teal (<u>Anas discors</u>), 1 green-winged teal (<u>Anas crecca</u>), 1 ruddy duck (<u>Oxyura jamaicensis</u>), and 5 unidentified.

[b] Two American coots (<u>Fulcia americana</u>), 1 great blue heron (<u>Ardea herodias</u>), 1 lesser yellowlegs (<u>Tringa flavipes</u>), 1 northern harrier (<u>Circus cyaneus</u>), and 1 horned lark (<u>Eremophila alpestris</u>).

In proportion to their abundance, whooping cranes were the most frequent casualties. The number of whooping cranes sighted in the San Luis Valley during 1983-84 ranged from 13-29. In addition to the three powerline kills documented during this period, two whooping cranes struck powerlines and survived. One was apparently unhurt; another sustained a fractured wing near Grand Junction, Colorado, was subsequently captured, its wing amputated, and transferred to Patuxent Wildlife Research Center in Maryland in May 1984. All but one of these five birds were juveniles.

Juvenile sandhill cranes collided with power lines far more frequently than adults (Chi-square = 72.98, 1 d. f., $p<0.001$). Age was determined for 43 crane strikes; 21 (48.8%) were juveniles. The mean percent juveniles in the San Luis Valley during 1983-84 was 9.9%.

Seventy birds (60.9%) were found under transmission lines and 45 (39.1%) under distribution lines. Relatively short sections of a few transmission lines accounted for most strikes; distribution line strikes were generally isolated incidents scattered throughout the valley.

Powerline distance from roost and feeding areas appeared critical to the incidence of strikes. Bird strikes were not found where the distance exceeded 1.6 km, whereas, 101 (87.8%) occurred where a line bordered or bisected a major use area and birds were taking off and landing in the immediate vicinity.

Experimental 115 kv Transmission Line

Fifty-four birds (36 cranes) were found under the 13 spans of experimental transmission line in four seasons. The highest number (25) was found in spring 1983. After removal of the static wire, strikes declined substantially during fall 1983 and spring 1984. When four spans of static wire were replaced in fall 1984, bird strikes increased to 18 (Fig. 2). Most strikes (12) occurred where either standard or experimental wire was present. The number of strikes/span of standard and experimental static wire were two and four, respectively. Only six strikes were found under the nine spans without a static wire (0.7 strikes/span).

Effect of Weather

Dates and existing weather conditions were identified for 29 crane strikes. Twenty strikes (69.0%) occurred on days with high winds, fog, or precipitation. By contrast, only 73 of 196 (37.2%) total survey days had foul weather. A highly significant proportion of collisions occurred during foul weather (Chi-square = 12.48, 1 d. f., p<0.001).

There was also a strong relationship between the proportion of foul weather days in each seasonal survey period and the number of strikes found per kilometer of powerline monitored (Fig. 3). Strikes kilometer of line ranged from 3.0-4.8 during spring 1983 and spring and fall 1984 surveys; foul weather occurred on 38-50% of the days during these periods. In contrast, we found only 0.6 strikes/kilometer of line during the exceptionally mild weather (15% foul weather days) of fall 1983 surveys.

Bird Flight Observations

We observed 1,694 crane flights over powerlines. Flocks of 1-4 and 5-20 birds occurred with about equal frequency, comprising 92.5% of all observations. Larger flocks usually occurred when birds were disturbed. Flocks of 21-50 made up 6.9%; flocks >50 comprised only 0.6%.

Most cranes (71%) reacted to powerlines by flaring and adjusting their altitude at some distance away, usually at 25-100 m. Altitude above the top wire was >6 m for 61.9% of all flights. Only two cranes were observed flying under the conductor wire; none between the conductor and static wire. No collisions were observed.

Reaction distance and altitude appeared directly related to distance from flight origin and destination. For example, despite removal of the static wire, Area 1 had the highest proportion of birds reacting at <25 m (44.9%) and the highest proportion crossing at 1-3 m above the line (Table 2). Area 1 is situated between immediately adjacent roost and feeding sites, and birds fly <0.8 km before crossing this transmission line. Altitude is normally low for short flight distances and cranes require considerable adjustment to clear the top wire (about 18 m high).

Reaction distance and altitude were greater at Area 2, despite presence of the static wire which increased height of the powerline to 22 m. Roost and feeding sites at this segment of line are separated by >2 km. Area 4, a small distribution line separating roost and feeding sites by >3.5 km had the fewest birds (11.1%) reacting at <25 m; most showed no reaction. Additionally, 77.9% of flights cleared the top wire by >6 m.

It was apparent that cranes' maneuverability and control are impaired by high winds; several near-collisons were observed. Cameramen for EEI also noted the detrimental effect of wind (EEI Crane Study, Unpubl. Rept.). Meaningful observations during fog and precipitation were difficult to obtain, because these conditions limited visibility for observers as well as birds.

Wild flushes were observed on two different occasions at Area 1. Both incidents resulted when a large group of cranes was disturbed by a farmer entering his adjacent field. Fifty-two flights involving a total of over 700 individuals were recorded; 37 flights (71.2%) reacted at <25 m; 4 (7.7%) of these reacted at <5 m, and 30 flights (55.7%) cleared the top wire by only 1-6 m. A third wild flush, during which four cranes struck the powerline, was filmed by EEI cameramen at Area 1.

DISCUSSION

Mortality Surveys and Flight Observations

Our surveys provide an index rather than a true measure of powerline mortality in the valley. Because of the large number of powerlines, it was impossible to monitor every potential problem site. Further, unrecorded crippling loss probably adds significantly to strike mortality. Anderson (1978) and Faanes (1983 loc. cit.) estimated their searches accounted for only 58% and 26% of mortality, respectively.

Our results indicate that cranes are more vulnerable to wire strikes than waterfowl, and whooping cranes more vulnerable than sandhills. This is undoubtedly related to the large size and low maneuverability of cranes, particularly whooping cranes. Thompson (1978) noted that large birds in flocks are especially susceptible to collisons. However, some bias towards large species is probably inherent in mortality searches, because smaller birds are more readily removed by scavengers or simply overlooked.

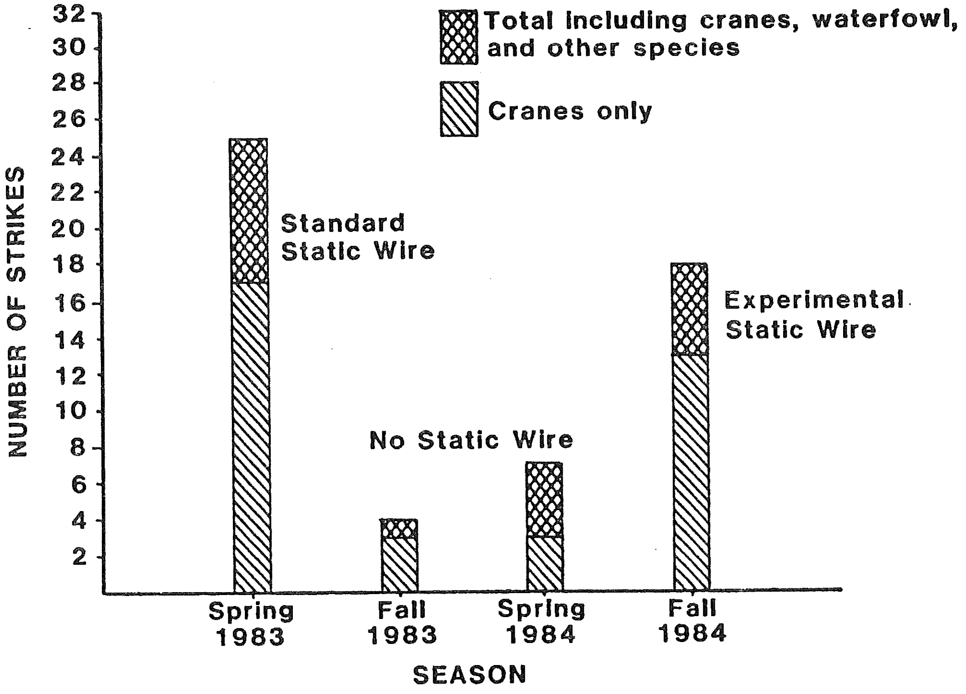

Fig 2. Number of bird strikes found beneath 13 spans of a 115 kv transmission line with experimental static wire modification during spring and fall crane concentration periods in the San Luis Valley, Colorado 1983-84.

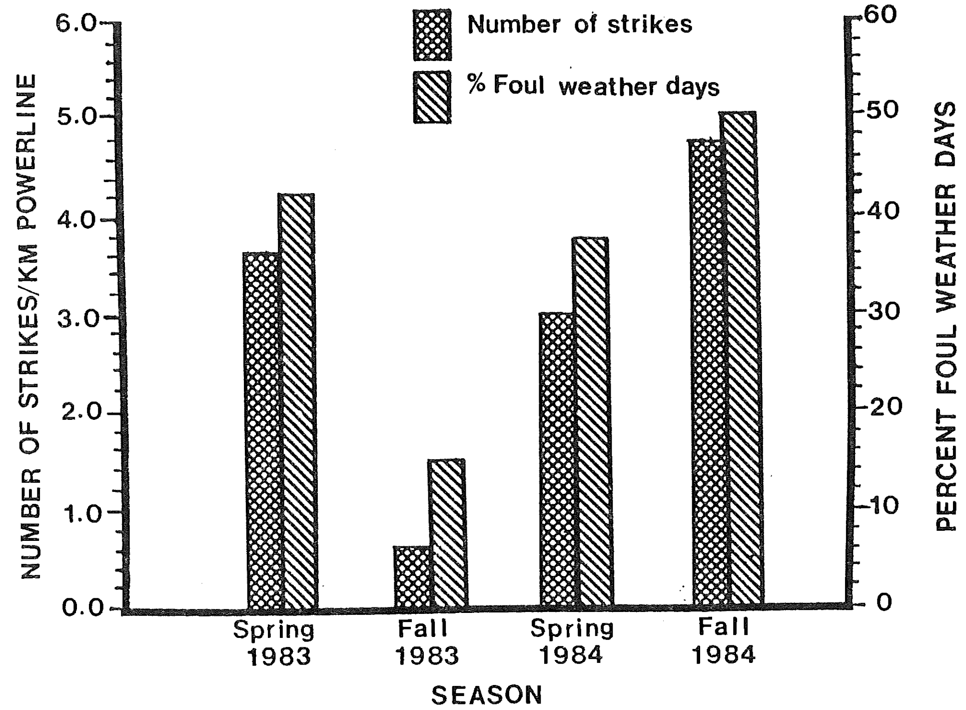

Fig. 3. Number of bird strikes found per kilometer of powerline and percent foul weather days during spring and fall crane concentration periods in the San Luis Valley, Colorado 1983-84.

Table 2. Reaction distance and altitude above line exhibited by cranes at four powerline study sites.

Observation area and powerline characteristics	No. flights observed	Reaction distance (m) and percent of observations				Distance (m) above line and percent of observations				
		<5	5-25	25-100	>100 or no reaction	Under	<1	1-3	3-6	>6
1 115 kv without static wire	463	0.9	44.9	41.7	12.5	0.2	0.0	6.5	39.3	54.0
2 115 kv with static wire	311	0.3	28.3	43.4	28.0	0.0	0.0	4.5	37.6	57.9
3 69 kv	353	0.0	27.2	46.2	26.6	0.0	0.0	2.6	42.2	55.2
4 7.2 kv distribution	515	0.1	11.1	41.0	47.8	0.2	0.0	3.1	18.8	77.9

Our results indicate that juvenile cranes strike powerlines more frequently than adults ($p<0.001$). Young birds lack flight experience and are no doubt less agile; they also lack familiarity with the area and its obstacles. Most researchers agree that these factors influence strike mortality (Thompson 1978). The proportion of juveniles in the cross-fostered whooping crane flock ranged from 35.7-59.4% during 1983-84 surveys, a factor which probably contributed to the high mortality of this species.

Although the magnitude of mortality from powerlines is unlikely to affect thriving populations of sandhill cranes and waterfowl in the valley, the impact on endangered species may be biologically significant (Lee 1978, Thompson 1978, Faanes 1983 loc. cit.). In the circumstance of cross-fostered whooping cranes, high juvenile mortality from powerline collisions impedes the buildup of a mature bird population necessary for intraspecies interaction and pair-bond formation.

Strikes occurred at both transmission and distribution lines, but were concentrated where transmission lines bordered heavy use areas. In equivalent locations, transmission lines are probably more hazardous than distribution lines because of their greater height.

Proximity of powerlines to roost and feeding sites appears most critical. No strikes were found >1.6 km from a roost or feeding site; most strikes occurred where at least one of these two habitats was adjacent to the line. Bird flight observations demonstrated that reaction distance and altitude are most reduced where a powerline separates two closely adjacent use-areas. The frequency of collisions increases because bird concentrations are high in such areas and frequent low-level flights are made across the line. Faanes (1983 loc. cit.) also found that interspersion of habitats at powerlines was important to the magnitude of mortality.

Inclement weather was a primary factor influencing the frequency of crane strikes at problem locations. The overall relationship between foul weather and strikes was highly significant ($p<0.001$) However, our sample size was insufficient to partition the individual effects of high winds, fog, or precipitation for statistical analysis.

The apparent increased vulnerability of cranes to wire collisions during inclement weather or poor visibility has been previously noted by Walkinshaw (1956), Wheeler (1966), Nesbitt and Gilbert (1976), and Tacha et al. (1978). Measures to increase visibility of problem lines are especially needed in the San Luis Valley, because adverse weather is common during crane-use periods. Increased strike mortality during inclement weather has been reported for other species by Scott et al. (1972) and Lee (1978), however, researchers were unable to establish a definitive relationship between fog and increased mortality of gulls and waterfowl in an Oregon powerline study (James, B. W., and B. A. Haak. 1979. Factors affecting avian flight behavior and collision mortality at transmission lines. Unpubl. Rept., Bonneville Power Admin., Portland).

Observations also indicated that strikes are likely to occur when birds are flushed near powerlines. Feeding sites in the valley are primarily agricultural fields with easy access by county roads, affording ample opportunity for human disturbance.

Experimental Transmission Line

Because of its location between adjacent, heavily used roost and feeding sites, the experimental line (Fig. 1) presents the greatest hazard of any powerline studied. However, results indicate that static wire removal significantly reduced mortality. Strikes declined markedly after the static wire was removed from the experimental segment (13 spans) in fall 1983, and increased only slightly during the adverse weather of spring 1984. When four spans of static wire were replaced in fall 1984, the number of strikes in the experimental segment increased substantially. Furthermore, 67% of strikes in the experimental segment occurred under spans where static wire (standard and enlarged) was present, whereas, these spans constitued only 31% of the total experimental area. Similarly, a study in Oregon reported 35% and 69% reduction in avian mortality after static wire removal at two sites (Beaurlaurier, D. L. 1981. Mitigation of bird collisions with transmission lines. Unpubl. Rept., Bonneville Power Admin., Portland). Faanes (1983 loc. cit.) estimated static wire removal could reduce strikes by 80% at one site in North Dakota.

Although larger samples are needed for statistical evaluation, preliminary results obtained in fall 1984 suggest that the enlarged static wire was much less effective than static wire removal in preventing collisions. Because of the small sample size, it is impossible to analyze the difference in the number of strikes found beneath standard and enlarged static wire (4 and 8 birds, respectively), however, the results certainly suggest that the enlarged static wire represented no improvement.

These preliminary findings do not support the hypothesis posed by Thompson (1978) and Faanes (1983 loc. cit.) that increasing the size of static wire should reduce mortality. It may be that larger size alone does not sufficiently increase visibility under variable light conditions. The dark, non-specular wire used in this study shows up well against overcast skies, but is less visible on sunny days because it fails to reflect light (Thompson 1978).

Color-marking the static wire may have more potential. Beaulaurier (1981 loc. cit.) summarized the results of 17 studies and found that marking powerlines with colored devices such as orange aviation marker balls, black and white ribbons, and luminous tape reduced avian mortality by an average of 45%. Similarly, installation of various yellow marking devices reduced powerline mortality of red-crowned cranes (_G. japonensis_) by about 43% in Japan (from 60% of total deaths to 34%, Yamaguchi, M. 1984, Letter to Chief, Endangered Species, Region 2. U. S. Fish and Wildlife Service).

RECOMMENDATIONS

Construction of new transmission lines within 2 km of traditional roost or feeding sites should be avoided. Under no circumstances should new transmission or distribution lines divide adjacent, heavily-used roost and feeding sites. New distribution lines needed in critical crane-use areas might be buried underground; this is technically feasible and in some situations less expensive than overhead construction (Thompson 1978).

Line modification or other measures to reduce mortality are needed where powerlines are already present in critical areas. Habitat modification to discourage crane use of hazardous areas seems unlikely on private lands. However, education of the local public regarding the danger of frightening birds near powerlines might reduce strikes caused by wild flushes. Static wire removal has been demonstrated to reduce mortality in this and other studies and should be employed when possible. However, because static wire removal increases the probability of lightening-caused power outages, other means of static wire modification should be explored. Comparative studies of the enlarged static wire with technically and economically feasible color marking devices are needed so that effective modification can be made at specific, critical areas where strikes perennially occur.

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SANDHILL CRANE MORTALITY AT CEDAR LAKE, TEXAS - AN OVERVIEW

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Abstract: An estimated 5,000 sandhill cranes (*Grus canadensis*) died from undetermined cause(s) at Cedar Lake and surrounding area in Gaines County, Texas, in January and February, 1985. At least 2,000 deaths occurred at Cedar Lake, a major roosting area used by an estimated 25,000 cranes. The balance of the mortality was distributed primarily between two feeding areas 4.5 km away. Dead cranes were picked up in cotton, peanut, and sorghum fields. No pathogenic bacteria or viruses were isolated from tissues and brain cholinesterase was not inhibited, ruling out most organophosphate pesticides and carbamates. Mycotoxins seem the most likely cause of this die-off and laboratory assays are continuing.

PROCEEDINGS 1985 CRANE WORKSHOP

Sandhill cranes traditionally migrate from their nesting grounds in the tundra and boreal forests of northern Canada, Alaska, and the Soviet Union each fall to western Texas. Thousands of cranes winter in western Texas roosting in shallow lakes and feeding in nearby harvested agricultural fields, grasslands, and pastures (Iverson et al. 1985). Cranes often arrive before harvesting is complete and can cause crop depredations. As a result of these depredations, a hunting season was implemented in the early 1960's.

The lesser sandhill crane (*G. c. canadensis*) is the predominate subspecies using the Gaines County area in western Texas, and Cedar Lake is a major roost site for these cranes.

Major outbreaks of infectious diseases have not been noted previously in this area, but local Texas Parks and Wildlife Game Wardens have reported annual losses of 100-300 sandhill cranes at Cedar lake for several years. Aflatoxicosis was believed to have been the cause of mortality of approximately 450 cranes at Cedar Lake in 1982 (National Wildlife Health Laboratory [NWHL] files). The source of the aflatoxin was not established. In other parts of southern United States many types of crops, including peanuts, corn, and sorghum are known to grow molds that produce aflatoxins (Edds 1973). Waterfowl losses from aflatoxicosis have been attributed to feeding on moldy peanuts (Robinson et al. 1982).

Peanut production has increased in portions of Gaines County in recent years and crane usage of these fields after harvest has increased accordingly. Time and method of harvest affects the percentage of peanuts that are not recovered; 20 to 30% may remain on the surface of the field.

We gratefully acknowledge the field assistance of personnel from Muleshoe and Buffalo Lakes National Wildlife Refuges, the U. S. Department of Interior - Fish and Wildlife Service Regional Office at Albuquerque, and the Texas Parks and Wildlife Department. Laboratory support at the NWHL was provided by J. C. Franson, R. K. Stroud, D. E. Docherty, and R. M Duncan. Cooperating personnel from other diagnostic laboratories include D. Zoromski, Wisconsin Central Animal Health Laboratory; E. Hill, Patuxent Wildlife Research Center; O. L. Shotwell, U. S. Department of Agriculture (USDA) Mycotoxin Laboratory; and R. J. Cole, USDA National Peanut Research Laboratory. F. M. Fisher, Rice University, provided radioscopic analysis of crane gizzards.

STUDY AREA

Cedar Lake is approximately 47 km southwest of Lubbock, Texas. It is 1.3 km wide and 2.5 km long. Less than 20% of the lake had standing water (2.5 to 10 cm) present during January and February, 1985 when this die-off occurred. The lake is highly alkaline and does not readily freeze; cranes used the mud flats for roosting where they were safe from predators. Cranes leave the lake each morning, dispersing up to 7 to 9 km to feed, and return each evening. Cranes roosting on the lake do not drink the highly alkaline water but stop at freshwater ponds or marshes to drink either enroute to the feeding area or on their return to the roost.

Mortality occurred primarily on two feeding areas approximately 4.5 km from Cedar Lake. Both feeding areas where cranes were observed dying had been irrigated by pivot irrigation systems but other fields used by cranes also had been irrigated. Crops consisted of peanuts and cotton, with the pivot turn corners planted in milo, black-eyed peas, and winter wheat. During the die-off, winter wheat was the only crop that was growing, the other crops had been harvested the previous fall.

METHODS

Areas where cranes were feeding were surveyed for carcasses by air and ground checks in late January and early February. Carcasses were collected for examination and to prevent further contamination of the area if an infectious disease was involved. All-terrain-vehicles were used to expedite carcass retrieval from the area. Nine sick cranes were caught by hand and blood samples and cloacal swabs were taken before euthanasia. These carcasses were then sent to NWHL for necropsy. An additional 12 cranes found dead were necropsied in the field and 14 others at NWHL. The remaining carcasses were incinerated in the field with a portable gas incinerator. An additional 18 cloacal swabs were taken on dead cranes for viral examination. Gizzards were removed from 120 cranes in the field for food and lead shot ingestion analyses.

Dead cranes on the mud flats at Cedar Lake could not be removed because of the deep mud. Carcasses accessible by foot through the deep mud were marked with red paint and the area checked periodically to detect new mortality.

RESULTS AND DISCUSSION

We estimate 900-1,000 sandhill cranes died on roost sites at Cedar Lake in late January and the first week of February, 1985. Additional losses of 1,200-1,500 were lost on shorelines and uplands immediately adjacent to the lake and in feeding areas. Texas Parks and Wildlife personnel stationed in the area estimate 2,500 more cranes died later in February making a total of approximately 5,000 sandhill cranes that succumbed during the die-off.

Sick and dead sandhill cranes were found in only two of the numerous feeding areas being used even though other areas contained similar crops. The two feeding areas were approximately 4.5 km west of the roost site and about 1.2 km from each other. At these two feeding areas, 474 carcasses were picked up in cotton fields, 156 in peanut fields, and 88 in milo, wheat, and soybean fields. Other feeding fields in the same vicinity were checked for sick and dead cranes, but less than six were found in any of the other fields.

Very few or no carcasses were found in other fields although the same crops mentioned above were being used by cranes. One harvested peanut field, for example, was being used by an estimated 12,000 birds and only 1 scavenged carcass was found. Similar findings occurred in other feeding areas although none of the others were observed to receive such heavy use. Mortality continued until the cranes migrated northward in late February and early March.

Sick cranes, if able to fly, could do so only with great difficulty. In flight, the birds were incapable of holding their necks horizontal and were observed flying with head, neck, and occasionally legs drooped perpendicular to the body axis. Affected cranes were uncoordinated and often landed with difficulty. Cranes incapable of flight would stand motionless with head drooped low to the ground; when approached, they were often unable to raise their head or neck.

Various lesions were noted at necropsy. The most predominant were submandibular edema, congested oral cavity, and hemorrhages in the lower intestinal tract. Kidneys from several birds were swollen and pale; hemorrhages were often observed in the breast musculature and upper muscles of the legs. Peanuts were present in about 95% of 120 gizzards examined from sick and dead cranes. None of the gizzards contained ingested lead shot. All birds examined were in good flesh indicating that a chronic disease process or poisoning was not the cause of the die-off.

Laboratory assays continue in an attempt to determine the cause of this die-off. The most likely etiology is a mycotoxin associated with ingestion of moldy peanuts. Aflatoxin, ochratoxin, and zearalenone, (the most common mycotoxins) have been eliminated from consideration. Pathogenic viruses or bacteria were not isolated nor was evidence of an infectious disease observed in microscopic examination of tissues. Organophosphate and carbamate pesticides frequently used in the area were also eliminated because brain cholinesterase was not inhibited. Arsenic, used as a defoliant in cotton production, was also eliminated by chemical analysis of crane tissues.

Additional analyses of tissues, gizzard content, and muscle for less common and newly discovered mycotoxins are being done at the USDA National Peanut Research Laboratory in Dawson, Georgia, and at the USDA's Mycotoxin Laboratory in Peoria, Illinois.

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IMPACTS OF THE TINCUP LOOP TRANSMISSION LINE ON CRANES IN CARIBOU COUNTY, IDAHO

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Abstract: We investigated the activity of sandhill cranes (_Grus canadensis_) and other avifauna from 1982-1984 along a 2 km segment of transmission line corridor located on private land. Activity prior to and after construction of a 161-kv single circuit 3-phase transmission line was monitored during all diurnal periods. Before constructing the line, nine pairs of breeding cranes were observed in the project area; three breeding pairs were observed after construction of the line. Evidence of three crane mortalities was found near the line along with five other known species of birds. Sandhill cranes were not observed striking the line during the study. However, a number of aborted flights, spirals to gain height, leg lifting, and flare flights were noted. Flare flights were frequent in one segment of the line where orange marker balls had not been placed. One whooping crane used the area in 1983. The potential for extensive whooping crane (_G. americana_) use in the area exists chiefly as a result of the sandhill crane foster parent experiments in progress at Grays Lake National Wildlife Refuge 22 km northwest of the study area. Three great blue heron mortalities were directly attributable to the line.

PROCEEDINGS 1985 CRANE WORKSHOP

During the past decade there has been increased interest by the public, government agencies, and electrical utilities in the hazards that electrical transmission lines present to migratory birds. The Rural Electrification Administration (REA), working in concert with cooperative utilities, has provided low cost funding for transmission and distribution lines throughout many sections of the United States. For migratory birds, this has established a potentially lethal grid system throughout the United States. However, the REA, in some respects, has been exemplary in answering public concern about migratory birds' deaths, e.g., the acceptance and circulation of Bulletin 61-10 (USDA 1979). Numerous studies have been conducted to refine techniques and create new methods for reducing collision and electrical hazards to migratory birds (Beaulaurier 1981, Olendorff 1981). Through Federal and State processes, efforts have been made to establish better planning and review methods for the rights-of-ways (ROW). However, only a limited number of post-assessment programs have been employed to study the efficacy of mitigation efforts initiated during the planning process.

The following is a case study on the effects of one powerline on sandhill cranes. In 1981, Lower Valley Power and Light (LVPL), a cooperative utility based in Afton, Wyoming, in its evaluation of electrical service requirements predicted power insufficiencies for the 1990's. As a result, LVPL applied for REA funding to build a 62.4 km single circuit 161 kV 3-phase power transmission line (Tincup Loop) in Caribou County, Idaho.

Objectives of pre- and post-construction biological studies were to evaluate the occurrence of cranes, waterfowl, and shorebirds in wetlands through which the line was to be constructed, evaluate the effects of the powerline configuration on cranes' flight patterns, and document avian mortality caused by the powerline and transmission poles. In June, 1982, before construction of the Tincup Loop transmission line, studies were intitated to assess possible impacts to the avifauna. After the line was completed, follow-up impact studies were conducted in the summer of 1984.

Appreciation is expressed to Power Engineers, Inc. Hailey, Idaho for funding assistance, routing maps, and technical information. The Caribou National Forest provided welcome assistance for housing and field support. The authors also acknowledge the U.S. Fish and Wildlife Service for additional funding assistance to complete these studies.

STUDY AREA

The confluence of Diamond and Lanes creeks (DLC), located on private lands, marks the beginning of the Blackfoot River (Fig. 1). Meadows adjacent to these creeks contain intermittent wetlands used as spring and summer habitat by breeding and juvenile sandhill cranes, and a variety of nesting waterfowl and shorebirds. Approximately 2 km of the ROW corridor for the Tincup Loop transmission line traverses this wetland.

The line was constructed during 1982 and 1983. Single wooden poles bearing davit-arm supports were used in the DLC wetland area. The individual cardinal conductor wires are 3.0 cm in diameter. A single ground wire 9 mm in diameter was used to diminish pole and conductor damage caused by lightning. Single 51-cm-diameter red Airway markers were placed centerspan on the ground wire at an average height of 18.2 m above ground level. Markers were placed through segments 2 and 3 of the line. Poles were placed at 100 m to 122 m intervals. Pole placement and stringing procedures were completed largely by means of helicopters in order to reduce vegetation and soil disturbance.

METHODS

Flight patterns of cranes were monitored along five segments of the various proposed routes of the transmission line in 1982 (Hupp and Connelly 1982). Each segment was monitored during 12, 1-hour observation periods. Observations were pooled for data analysis and evaluated using chi-square goodness-of-fit tests. The hypothesis was tested that cranes were evenly distributed among airspace in the study area. If the hypothesis was true, observations on each segment should have been proportional to segment length.

As a result of extensive flooding of the DLC area, the 1984 post-construction studies were not initiated the same date as the Hupp and Connelly (1982) study but were delayed 10 days until 15 June. However, additional time was spent in the area through 19 September 1984 to document line collision mortalities (Keller and Rose 1984). Data were collected on line

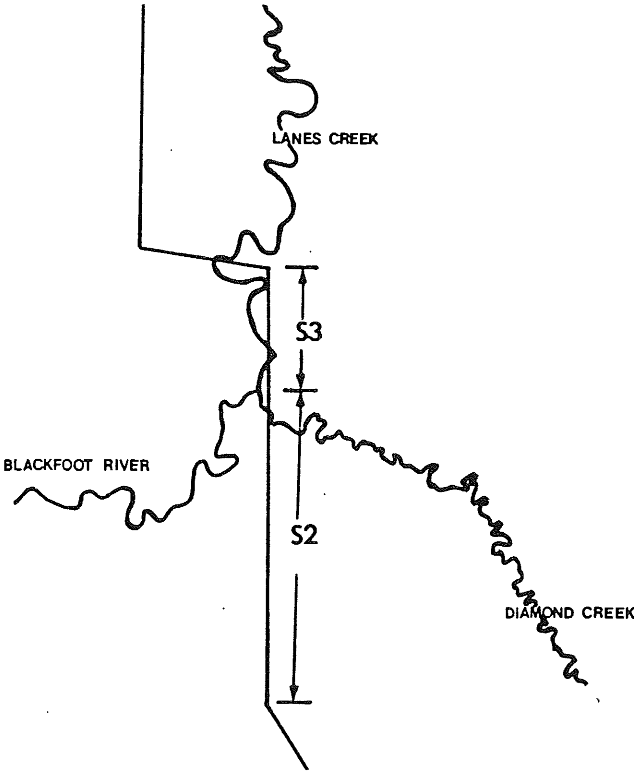

Fig. 1. The confluence of Diamond and Lanes creeks marks the beginning of the Blackfoot River. The solid black line depicts the Tincup Loop power transmission line that bisects the study area.

crossing patterns of birds, and wire strikes or near misses. Ground surveys were made to find dead birds and sandhill crane nests. Bird flights through the study area were monitored during 16, 1-hour observation periods. All observations were made with the aid of spotting scopes and/or binoculars. Span lengths were unequal in the 2 km reach of the transmission line, as assumed in the Hupp and Connelly study (1982), so the chi-square statistic could not be used to compare frequencies of crossings over the two locations. To resolve this problem, frequencies of crossings before and after construction were compared by dividing the total number of crossings of cranes by the number of observation intervals for both studies.

Systematic ground searches for dead or crippled birds were conducted along parallel transects walked by four individuals spaced at approximately 10 m intervals on each side of the powerline corridor. The area adjacent to the powerline was also searched along transects spaced at 50, 150, 250, and 350 m intervals for nesting sandhill cranes and dead or crippled birds.

RESULTS

Sixty-three avian species were observed in the study area. A total of 4,421 individual birds entered airspace near the two transmission line segments. One common snipe (Capella gallinago) and one unidentified gull were observed striking a conductor wire in segment 2 of the transmission line. Neither bird was killed, although they may have died later due to injuries sustained in the collisions. Sandhill cranes were predicted to use segment 2 on a significantly higher frequency than if the birds were randomly distributed (Table 1). In contrast, cranes were predicted to use segment 3 on a significantly lower frequency than if they were randomly distributed. Sandhill cranes were not observed striking the conductors, poles, or ground wire during the observation periods (Keller and Rose 1984). Average counts of avifauna in both segments 2 and 3 were significantly greater in Keller and Rose's study (1984) than in Hupp and Connelly's (1982) when adjusted for the difference in the number of periods (Table 2). This difference can be attributed to a greater number of gulls and shorebirds in the airspace over segment 2. In segment 3, fewer larger gulls and shorebirds were observed but greater numbers of sandhill cranes, small gull, and waterfowl were reported.

A number of aborted flights, spirals to gain height, leg lifting, and flares were noted when cranes encountered the powerline. Flares were commonly noted on the south end of the transmission line in a segment where airway markers were absent. Pooled data (Table 3) for sandhill cranes show that individuals are flying over more often than under the line in Segments 2 and 3.

Three sandhill crane mortalities were documented along with those of five known and two unknown bird species in segments 2 and 3 of the power line. Three great blue heron mortalities were directly attributed to the presence of the conductor or ground wires. The data are too limited, however, for statistical interpretation of removal bias as discussed by Beaulaurier (1981). Hupp and Connelly (1982) observed nine pairs of breeding cranes within 400 m of the proposed line whereas Keller and Rose (1984) observed only three breeding pairs. One pair had abandoned their nest leaving one unhatched egg. All locations were within 150 m of the power line right-of-way.

Table 1. Chi-square goodness of fit tests for sandhill crane observations during flight pattern surveys on line segments 2 and 3 near Diamond/Lanes creeks confluence.

Category	Segment 2	Segment 3
Cranes observed	34 (0.60)↑[a]	2 (0.04)↓[a]
Cranes expected	18 (0.32)	14 (0.25)
Confidence limits	13.2	10.7
95% Confidence limits	0.42<P<0.76	0.0<P<0.097

[a] Failure of the expected proportions to fall within the confidence interval (a) indicates that numbers of flights on this segment of power line were significantly higher (↑) or lower (↓) than would occur if birds were randomly distributed.

Table 2. Contrast of pre- and post-construction avian airspace use (corrected for dissimilar observation periods to indicate average number of flights per hour of observation).

Avian category	Segment 2		Segment 3	
	Before	After	Before	After
Large gulls	2.2	3.6	0.8	0.4
Small gulls	18	73.9	25.8	137.5
Shorebirds other than gulls	4.9	11.1	11.0	3.6
Sandhill cranes	2.8	2.8	0.2	1.4
Waterfowl	3.4	2.1	0.5	3.8

Table 3. Sandhill crane flight pattern positions when crossing the Diamond/Lanes creeks segment of the Tincup Loop transmission line.

	Flights path in relation to lines			
Segments 2-3 (spans 1-18)	Over	Under	Within	Total
Sandhill crane flights	61	18	3	82

DISCUSSION

Three cranes, three great blue herons, and six other avian species were found dead near the Tincup Loop transmission line within 1 year after construction. The transmission line was routed through the confluence of two creeks that are surrounded by intermittent wetlands. With regards to these mortalities, no attempt was made to assess search, habitat, or crippling bias. It is probable that habitat bias may be the most important factor because the transmission line traverses significant amounts of water that might sweep dead birds from view.

The lower number of breeding pairs found in the study area after the line was built may be a result of temporary rather than permanent displacement (Thompson 1977). High water conditions in 1984 may have reduced nesting habitat and precluded additional nesting in the area. Monitoring should continue in the area to identify the variables affecting breeding sandhill cranes.

It is obvious that segments 2 and 3 in the study area are intensively traversed by sandhill cranes and other avifauna. The power line has caused significant shifts in flight patterns of other avian species and created a hazard for cranes. The potential exists for whooping cranes to extensively use the area as a result of the sandhill crane foster parent experiments in progress at Grays Lake National Wildlife Refuge, approximately 22 km northwest of the study area. Indeed, one whooping crane was observed using the DLC area in 1983 (R.C. Drewien, Idaho Coop. Wildl. Res. Unit, Moscow ID pers. commun.).

Hupp and Connelly (1982) concluded, before the power line was built, that because of the intensity of crane flights crossing segment 2, and because a high proportion occurred at an altitide where power lines would be encountered, the new line would pose a serious obstacle to flying cranes. Three variables crucial in reducing this lethal obstacle are ROW selection, line configuration, and line markers. The U.S. Fish and Wildlife Service had originally recommended that the line cross the Blackfoot River rather than cross in the DLC area, a distance of approximately 500 m. The Service also recommended that an H-frame pole design was preferable to the davit-arm construciton to reduce the potential collision zone. Further, the Service also suggested that not one but two Airway markers be placed on each span. These variables were considered by LVPL but were only implemented at a compromised level. LVPL retained their original ROW selection and the davit-arm construction, and placed only one Airway marker per span on a portion of the spans that FWS recommended should be marked. Because full mitigation efforts were not completed, Keller and Rose (1984) concluded that the DLC segment of the Tincup Loop transmission line presented an opportunity to evaluate a potential "worst-case" situation for cranes that should be carefully monitored.

With a significant number of power lines traversing areas of concentration of sandhill cranes, the total mortality pattern may be more significant than realized (Willard and Willard 1978). Finding more rigorous mitigation procedures and enforcing the ROW review process across private lands to reduce sandhill crane power line collisions should reduce the potential for whooping crane collisions. Funds also need to be made available to monitor mitigation recommendations and conservation measures that are made under the U.S. Fish and Wildlife Coordination Act and the Endangered Species Act. Such an effort is clearly needed because 13 whooping crane injuries or mortalities (8 in Grays Lake flock, 5 in the Aransas flock) have occurred due to power line collisions since 1956 (Brown et al. This Proceedings, Stehn 1985, J.C. Lewis pers. commun.).

Authors Postscript: On 23 September 1985 a juvenile male whooping crane was recovered on Diamond Creek about 14 km from the DLC confluence. The bird sustained injuries to one eye, wing, leg, and abdomen that were suggestive of impact with the nearby Tincup Powerline. Intensive care of the whooping crane was provided by DVM Josh Diem from the U.S. Fish and Wildlife Service Patuxent Wildlife Research Center and DVM Joel Volpi of Alpa Animal Hospital in Pocatello, Idaho. Unfortunately, on 2 October the crane died due to these impact injuries. The apparent strike occurred where the powerline crossed a lateral valley, rather than Diamond Creek Valley. This section of powerline is in a low probability strike zone when compared to the DLC section described in this paper.

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