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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.

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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.

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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.

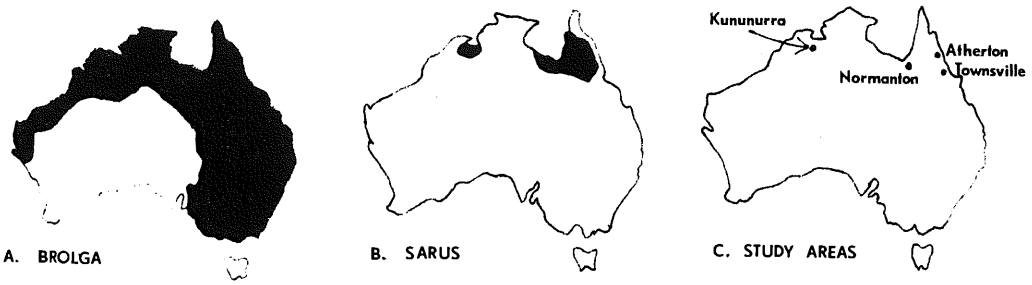

Fig. 1. Distribution of the brolga (A) and the sarus crane (B) in Australia (after Frith 1982); (C) locations where cranes were studied.

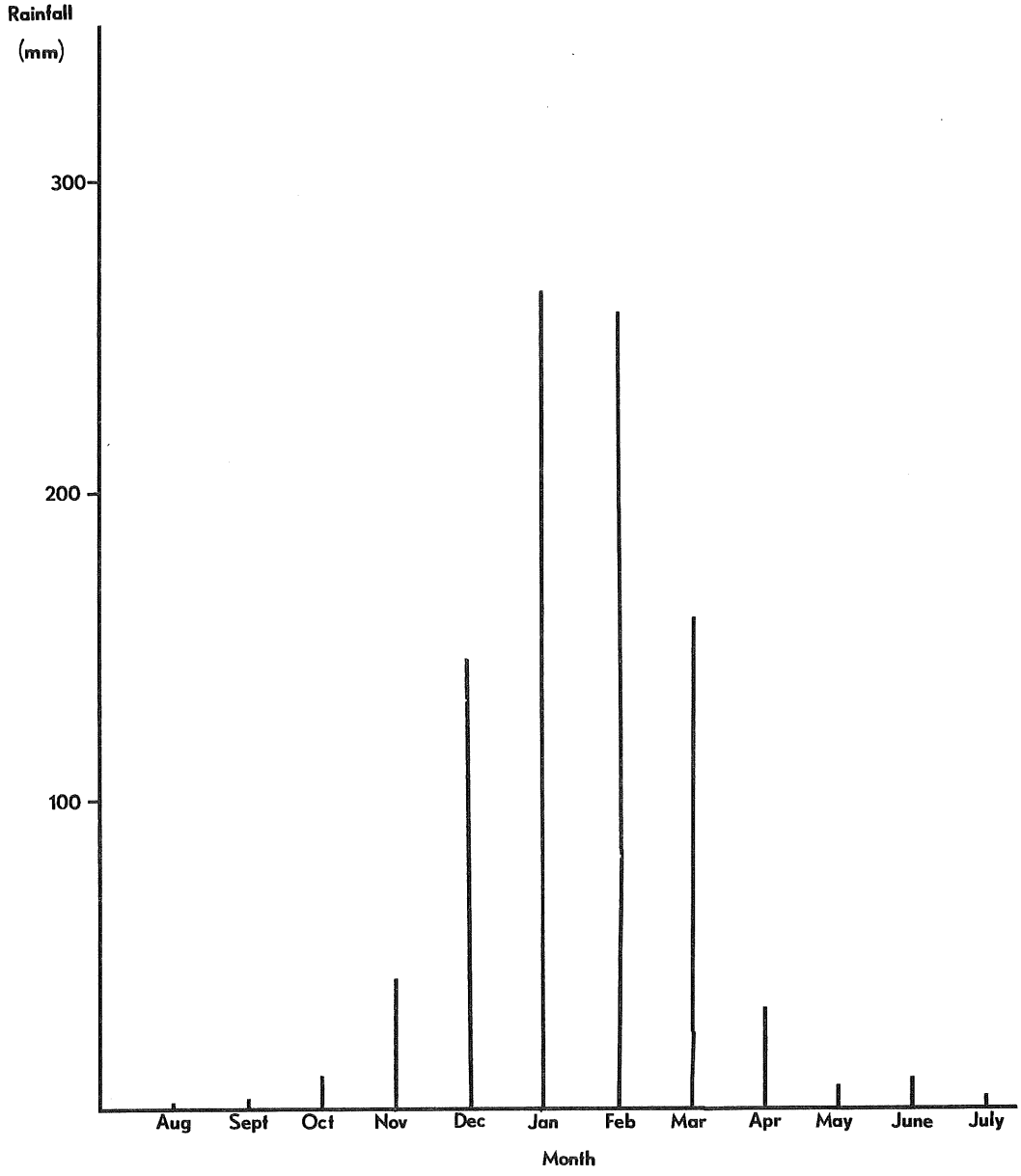

Fig. 2. Mean monthly rainfall at Normanton, Queensland, Australia.

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.

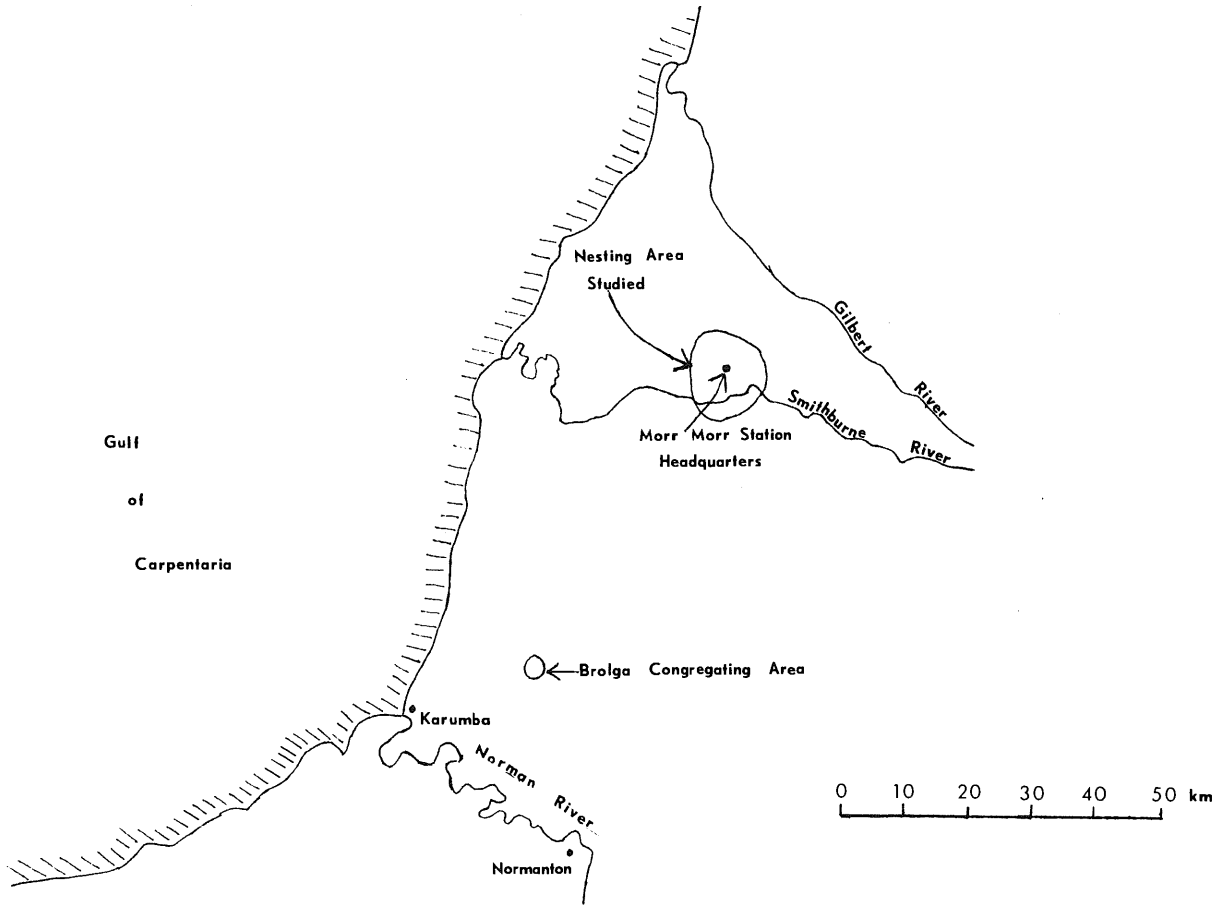

Fig. 3. The Normanton region, Queensland, 1984 study site.

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).

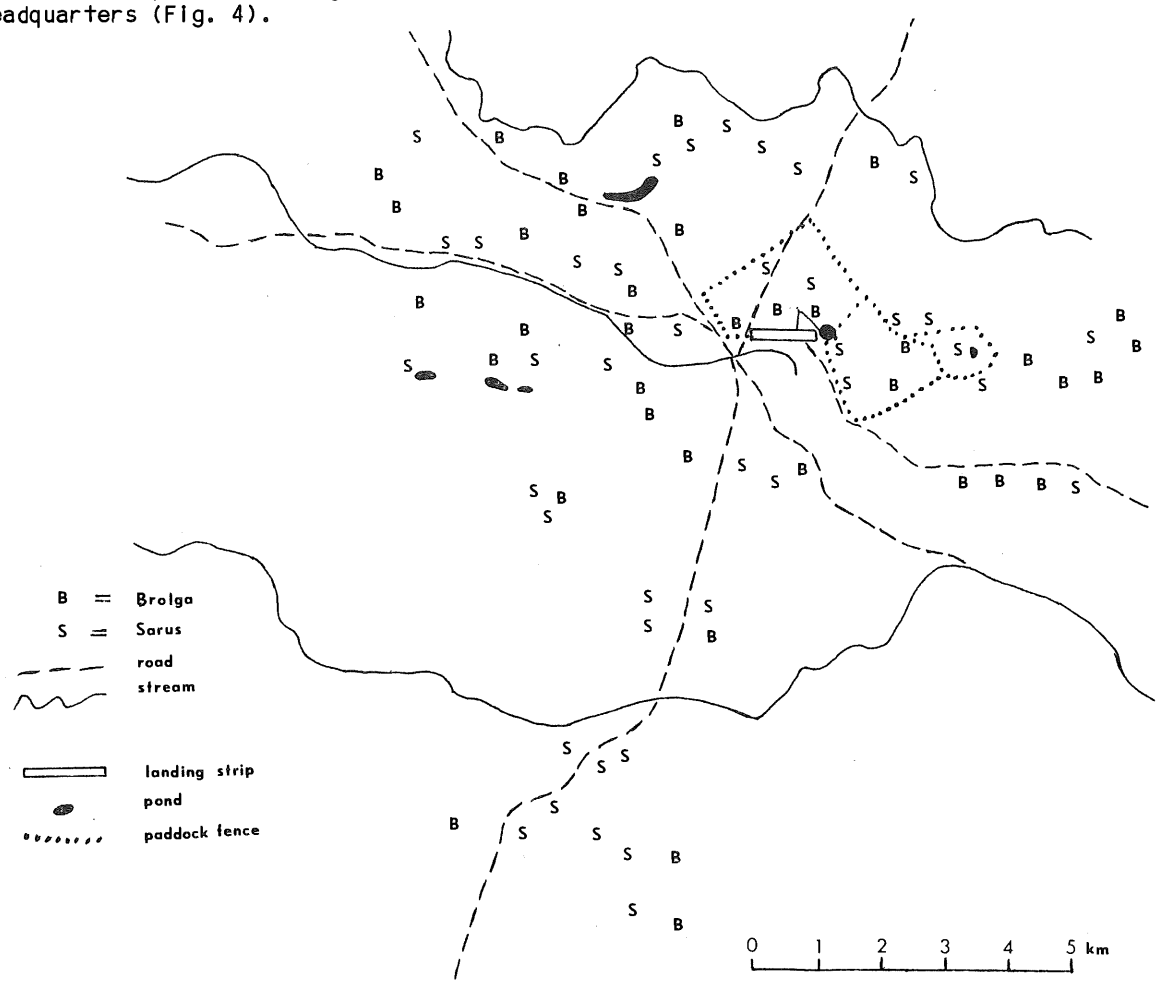

Fig. 4. Locations where nests of sarus and brolgas were found in the area around the Morr Morr Station headquarters.

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 (Scirpus spp.), rice grass (Heersia spp.), and sedges (Cyperus 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.

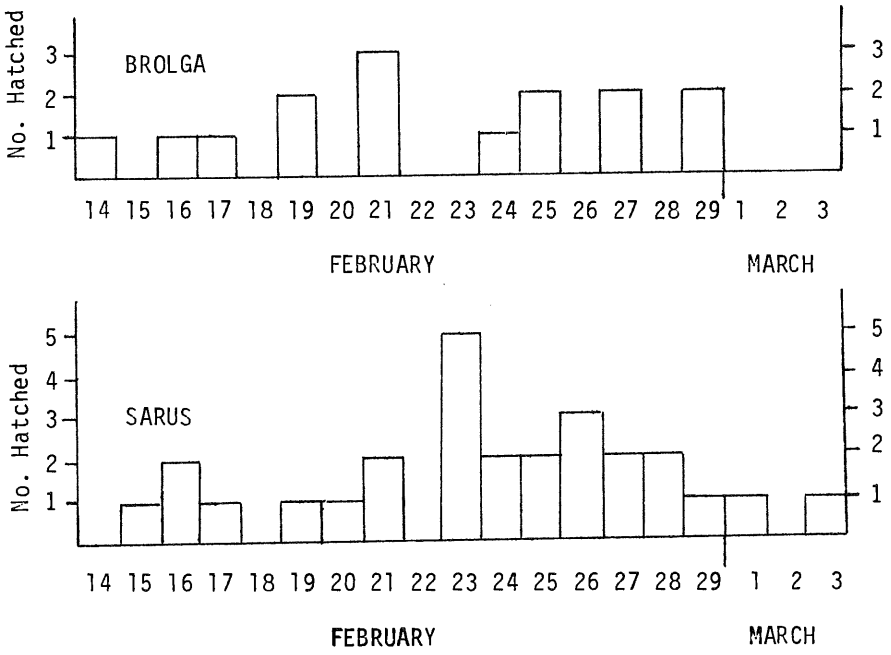

Fig. 5. Hatching dates of sarus and brolga eggs in 1984.

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.

LITERATURE CITED

Archibald, G. W. 1976. The unison call of cranes as a useful taxonomic tool. Ph.D. thesis, Cornell Univ., Ithaca, New York. 167 pp.

_____, 1981. Introducing the sarolga. Pages 213-215 in Lewis, J. C., and H. Masatomi, eds. Crane research around the world. International Crane Foundation, Baraboo, Wisconsin.

Blackman, J. G. 1971. Sex determination of Australian cranes (Gruidae). Queensland J. Agric. Anim. Sci. 28:281-286.

Delacour, J. 1935. Bird breeding at Cleres. Avicul. Mag., 4th ser., 13:24-25.

Frith, H. J., ed. 1982. Reader's digest complete book of Australian birds. Reader's Digest Serv. Pty Ltd, Surry Hills, NSW, Australia. 614 pp.

Ingold, J. 1984. Systematics and evolution of the cranes (Aves:Gruidae). Ph.D. thesis, Miami Univ., Oxford, Ohio. 62 pp.

Johnsgard, P. A. 1983. Cranes of the world. Indiana Univ. Press, Bloomington. 257 pp.

Lavery, H. J. 1970. The comparative ecology of waterfowl in north Queensland. Wildfowl 21:69-77.

Lavery, H. J., and J. G. Blackman 1969. The cranes of Australia. Queensland Agric. J. 95:156-162.

Walkinshaw, L. H. 1973. Cranes of the world. Winchester Press, New York. 370 pp.