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Cranes of the World: Sarus Crane (*Grus antigone*)

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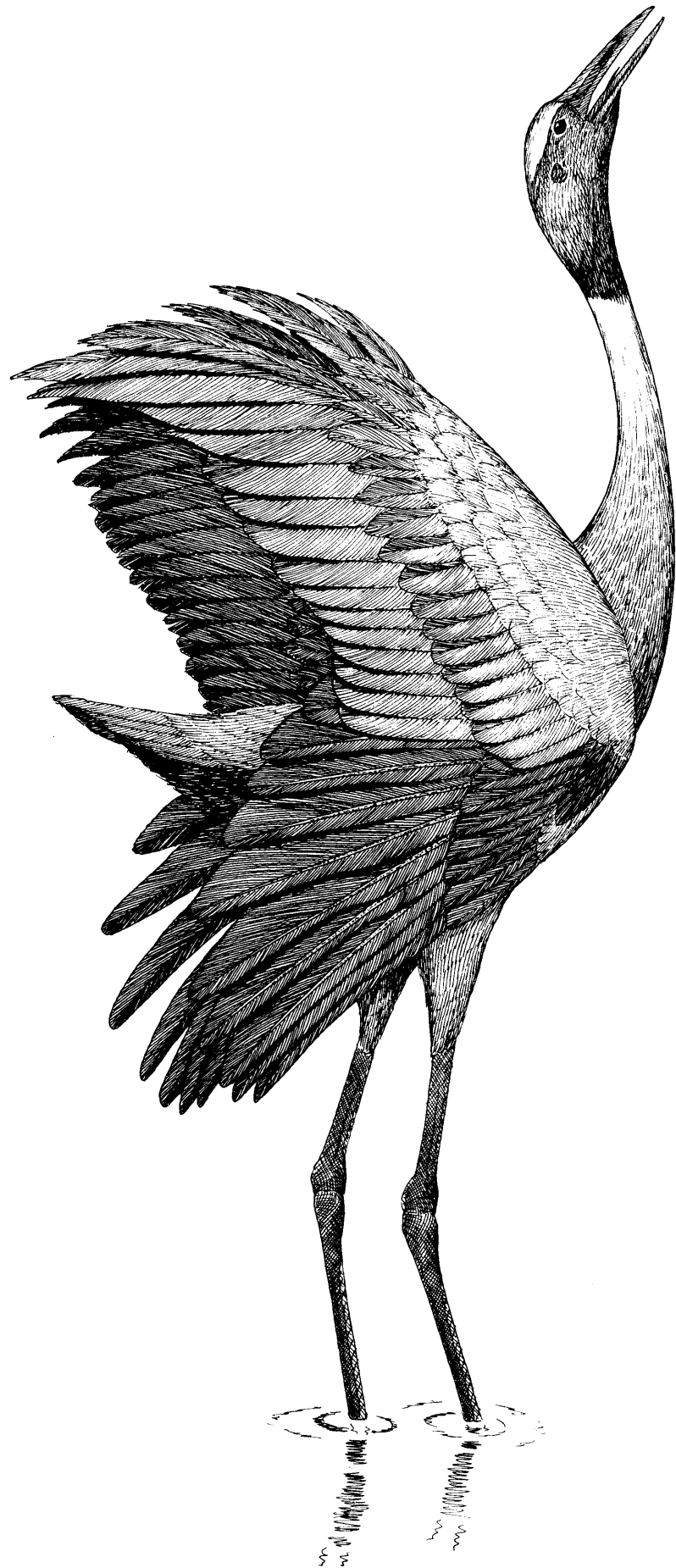


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Sarus Crane

Grus antigone (Linnaeus) 1758

Other Vernacular Names. Sharpe's crane; Khur-sang, Korchan (Assam); Grue antigone tropicale, Grue à collier (French); Sarus-kranich, Halsbandkranich (German); Saras, Sirhans (Hindi); O-O zuru (Japanese); Belyi zhuravl (Russian); Grulla blanco cuello (Spanish).

Range. Resident in northern India, east to Burma, on the Malay Peninsula, and in Indo-Chinese countries, and in northern Australia. Probably extirpated from the Philippine Islands, and perhaps also from Burma, Thailand, and Malaysia.

Subspecies.

G.a. antigone: Indian Sarus Crane. Resident in northern India from western Assam west to the Indus in Pakistan, and south to the Bombay area on the west and to the Godavari River on the east.

G.a. sharpei: Burmese Sarus Crane. Resident or former resident in Assam, Burma, the Malay Peninsula, Cambodia (Kampuchea), southern Laos, southern Vietnam, and northern Australia (Kununurra to Atherton). Formerly occurred in Thailand (at least to 1964) and also (perhaps still) on Luzon.

Measurements (both subspecies, *antigone* averaging slightly larger than *sharpei*). Wing (chord), males 514-675 mm (average of 16, 619.3 mm); females 557-671 mm (average of 11, 612.5 mm). Exposed culmen, males 156-187 mm (average of 16, 169.3 mm); females 155-169 mm (average of 11, 161.4 mm). Tarsus, males 269-352 mm (average of 16, 323.1 mm); females 272-350 mm (average of 11, 304.1 mm). Eggs, average 104.4 × 64.3 mm (93.2-113.2 × 53.8-69.8 mm) (Walkinshaw, 1973).

Weights. Five adult males (presumably of *sharpei*) averaged 8.4 kilograms (Archibald, 1981b). Specimens of *antigone* from India range from about 6,800 to 8,000 grams (Ali and Ripley, 1969). Estimated egg weight, 238 grams. Ten fresh *antigone* eggs averaged 212.56 grams (Walkinshaw, 1973).

Description

Adults of both sexes have the head, throat, and upper neck bare of feathers. The crown skin is smooth and pale ashy green, while the remaining bare areas are orange red and covered with coarse granulations, becoming brighter during the breeding season. The upper throat and some of the neck are covered with long, hairlike bristles, and a small area of grayish white feathers surrounds the ears. In *antigone* a ring of white feathers occurs between the bare neck and the gray neck feathering below, and the inner secondaries are also white, while in *sharpei* this white neck area is lacking and the body and wing feathers are generally darker, especially on the secondaries. The primaries, primary coverts, and alula are dark gray or blackish, and the innermost secondaries are lengthened and pointed. The other secondaries are darker on the outer webs and lighter on the inner ones. The remainder of the plumage is rather uniformly gray to bluish gray. The iris is yellowish brown to orange, the bill is greenish, with a darker tip, and the legs and toes are red, fleshy red, or bluish pink.

Juveniles have entirely feathered heads and necks, which are buffy in color. The feathers of juveniles are edged with brownish gray, and those of the upperparts are cinnamon brown, often with downy tips adhering.

Downy chicks are pale isabelline (yellowish brown) on the head, neck, and throat, becoming darker on the lower neck, the sides of the breast, the thighs, and the vent, and white on the center of the breast and on the belly. Two broad lines of dark brown extend from the base of the neck to the rump, enclosing a paler brown median stripe, and a large buffy white spot is near the base of each wing (Walkinshaw, 1973).

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Residential distributions of the Indian (diagonal hatching) and Burmese (vertical hatching) sarus cranes. Areas of light stippling indicate regions of prior or uncertain occurrence.

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Identification

In the field, this is the only resident crane in southeastern Asia south of the Himalayas, and the only crane of Asia that has both a generally grayish plumage and the upper neck and head bare of feathers and mostly reddish, except for a gray crown and a gray, feathered ear patch. Where the Australian crane might also occur (in northern Australia), the reddish legs of the sarus provide a good basis for the separation, as well as its absence of a dewlap at the throat, its bare, red head skin extending to its upper neck, and a whiter ear patch and inner secondaries.

In the hand, the very large size of this crane (wing usually over 600 mm) separates it from most other cranes, but the very similar Australian crane is nearly as large. The latter species lacks reddish legs, has less elongated and decurved inner secondaries, and the bare area of the head does not extend down to include the upper neck. The trachea of the sarus is coiled within the keel of the sternum.

DISTRIBUTION AND HABITATS

Historical Range

The historical distribution of the sarus crane is probably less different from its current distribution in India than in any other area. Ali and Ripley (1969) described it as extending through the northern parts of the Indian subcontinent south of the Himalayas (including the Tarai Lowlands of southwestern Nepal) from Sind and Punjab in Pakistan eastward through Uttar Pradesh, Bihar, and northern Bengal to western Assam in India. It apparently occurs fairly regularly at altitudes to about 1,650 meters, and rarely reaches as high as 1,700 meters (Kashmir Valley). It becomes more common below Dharmasala, Himachal Pradesh, and extends south through eastern Rajasthan, Gujarat, and northern Madhya Pradesh, reaching its limits at about a line extending from Surat on the west to the Godavari Delta on the east. According to Ali and Ripley, it is most numerous in Gujarat, eastern Rajasthan, and on the Gangetic Plain. In northeastern India (Assam) there are early breeding records for Dibrugarh and Chotta Bheel, Cachar (Walkinshaw, 1973).

Its western historical limits are in Pakistan, where breeding was recorded as far west as Hardoi, Northwest Frontier Province, in 1901 (Walkinshaw, 1973).

In Nepal the sarus crane has been collected at about 300 meters at Dhangarhi, which is near the Uttar Pradesh boundary of westernmost Nepal (Walkinshaw,

1973). Probably nearly all of Nepal is too high or arid to provide suitable breeding habitat, except for the "tarais" of the southwestern border.

Historically, the sarus crane in Burma was evidently fairly common over much of the country, but most common in central Burma and the Shan states, with breeding records known from Myitkyina in Kachin State, the Shweli River in Mongmit, and in the Shan Hills (Smithies, 1953). Walkinshaw (1973) reported eggs from Pegu, Martaban, and "lower Burma."

Farther south and east, the Burmese race of the sarus crane at least once bred in Thailand, with a nesting record from Muang Fang (Walkinshaw, 1973). King and Dickinson (1975) described its range as including central and peninsular Thailand, Cambodia, Cochinchina and southern Annam provinces in Vietnam, and southern and central Laos.

Although the sarus crane once occurred locally on the Malay Peninsula, extending south to Perak, there are apparently no breeding records for the peninsula (Medway and Wells, 1976).

Evidently the sarus was once fairly common in some areas of Luzon, the Philippines. Thus, it was reportedly once abundant in Cabanatuan of Nueva Ecija Province, and bred in open swampy areas of that province. It was also observed in the Candaba Swamp of south-central Luzon near Manila, and in Cagayan and Isabela provinces of northern Luzon (Madsen, 1981).

Prior to the 1960s, the sarus crane was not known to occur in Australia (Gills, 1969).

Current Range

According to Archibald et al. (1981) the sarus crane is now thriving in India, for the Indians have considered it a sacred bird since the early days of Hinduism, and it is strictly protected. The birds have lost their fear of man and prosper over much of northern India.

In Nepal, the sarus is now occasional in the damp, cultivated fields of the western tarai, and scarce in the central tarai (Fleming, Fleming, and Bangdel, 1976).

The crane's status in Burma is quite uncertain. King and Dickinson (1975) listed it as "resident" on the plains of Burma, but Archibald et al. (1981) considered it almost if not totally extirpated from Burma and Thailand, and of undetermined status in Laos, Cambodia, and Vietnam. Medway and Wells (1976) stated that there have been no recent reports of the species in the Malay Peninsula.

Madsen (1981) searched unsuccessfully for the sarus crane on Luzon in 1979, where she believes that although perhaps a few individuals may still exist, a sizable crane population is unlikely. There have been sightings of a single pair as recently as 1979 at Tabuk, Kalinga-Apayao Province, and other sightings in the 1960s for the municipalities of Jone, Ilagan, and

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Cauayan, all in the Cagayan River valley. The Philippines government is currently interested in starting a restocking program, using hand-reared birds of Australian stock (Archibald et al., 1981).

In Australia, the sarus crane was first identified in September of 1964, at Hasties and Willet's swamps on the Atherton Tableland in northeastern Queensland (Archibald, 1981b). Later in that same year, about 15 were reported at Normanton (Gills, 1969), and in 1967 a total of 23 individuals were counted among a flock of brologas (Lavery and Blackman, 1969). Blackman (1971b) reported seeing the crane at more than thirty localities in 1969, including one flock of 75 birds at Willet's Swamp. By 1972 at least 200 sarus cranes were present on the Atherton Tableland. The birds are apparently increasing and are also expanding their range, since they seem to be able to out-compete the slightly smaller brologa crane (Archibald, 1981b).

Habitat Requirements and Densities

Nesting habitats in India have been described by Walkinshaw (1973). The Keoladeo Ghana Bird Sanctuary area, where the birds nest commonly, is in a forestry region where many trees such as babul (*Acacia arabica*), kandi (*Prosopis spicigera*), and keli kadamb (*Stephegyne parvifolia*) occur in higher elevations and on the impoundments. Some dead trees also occur on the flooded marsh. The entire area is pastured by cattle and water buffalo, and during the rainy season no vegetation protrudes above the water for a time. However, soon after the rains begin, there is an extensive plant growth. The total annual rainfall is about 27 inches, mostly coming during the monsoon period. Nesting is tied to the wet period, and in years where nesting areas remain unflooded the birds may not nest at all, even though they may remain on the territory.

Walkinshaw found the pH of the water of Keoladeo Ghana to be about 9.0, while in another area (Baroda in Gujarat) where he found a nest in a sewer pond the pH was 7.2. Some of the plants growing in the vicinity of this pond included various grasses (*Oryza*, *Fatua*, *Paspalum*, *Echinochloa*), sedges (*Scirpus maritimus*), water lilies (*Nymphaea lotus* and *Limnanthemum indicus*), pulse (*Aeschynomene indica*), blue-green algae (*Lynghiya*), and other vegetation (*Limnophylla heterophylla*, *Melochia corchoriflora*).

The total area of the Keoladeo Ghana Sanctuary is 2,900 hectares, of which about 2,200 hectares are wet during the monsoon season. However, the water is seldom more than 1.5 meters deep anywhere in the sanctuary, and usually is from 0.6 to 1.0 meter deep (Sauey, 1976). Walkinshaw (1973) reported that he saw an average of 171 birds per day there in February of 1969, and a maximum of 308, while during September he saw as many as 103 birds in a single day. Since

September represents the breeding season, it might be judged that the breeding season density on the sanctuary is roughly one bird per 30 total hectares, or one per 20 hectares of wet areas. Nonbreeding densities may be about twice as great. In September Walkinshaw found three active nests, as well as others not yet ready for eggs, indicating that a bare minimum breeding density would be in the range of a pair per 400 hectares of water area. He states that after the start of the monsoon period and the onset of breeding behavior, he found no more than 27 pairs within the limits of the sanctuary, indicating a possible maximum breeding density of a pair per 80 hectares of water area. This would tally with his estimate of individual territories ranging from no less than 40 hectares to about 61 hectares at maximum.

In Burma, the sarus crane seems to occur in more isolated swamps and marshes than is true in India, while in its newly acquired range of Australia the species occurs much in the same habitats as does the Australian crane, although the two species tend to remain separated from one another (Walkinshaw, 1973). Lavery and Blackman (1969) state that the sarus feeds in freshwaters and cultivations, while the Australian crane occurs in these areas but also in grasslands, open forests, and saline areas. Vegetation of favored freshwater swamps of the sarus, such as Willet's Swamp, consists of sedges (*Rhynchospora*, *Cladium*), grasses (*Schoenus*), and herbs (*Eriocaulon*, *Melastoma*, *Philydrum*).

Nonbreeding habitats are evidently the same as breeding habitats, since the species appears to be essentially sedentary.

FOODS AND FORAGING BEHAVIOR

Foods of Adults

Most evidence indicates that this species is highly omnivorous. Plant materials that are eaten include grain from stubblefields, the tubers and corms of aquatic and marsh plants, the green shoots of grasses and cereal crops, the pods of groundnuts (*Arachis*), and the like (Ali and Ripley, 1969). Walkinshaw (1973) stated that during the harvest season the birds feed on waste wheat and gram (*Cicer arietinum*) and also strip ripened rice (*Oryza*) from the stalks. In Australia sarus cranes sometimes feed in cornfields, and also consume native grasses (Lavery and Blackman, 1969).

Insects, especially grasshoppers, are also commonly consumed. Walkinshaw (1973) stated that the cranes fed at times in very dry areas of the Keoladeo Ghana Bird Sanctuary where there are few seeds, and apparently ate grasshoppers and other insects. Likewise in northern Australia he observed them feeding on short-grass

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plains where grasshoppers were very abundant. Walkinshaw believed that aquatic snails may sometimes be eaten by sarus cranes.

Vertebrates are also consumed fairly regularly by sarus cranes. Walkinshaw (1973) observed an adult male killing a two-foot water snake (*Natrix piscator*) and feeding it to a youngster, then later the same bird caught a second snake of the same size and offered it to a smaller chick, which was unable to swallow it. The male then swallowed the snake, tail first. Spitzer (1979) also saw sarus cranes killing and consuming water snakes on several occasions, and once saw a crane kill a large frog but later drop it and lose interest in it. Fish have also been reported as a minor food source for sarus cranes (Law, 1930).

Foods of Young

As noted above, the chicks are fed by the adults for a prolonged period; the chick that Walkinshaw saw being fed a large water snake was about two-thirds grown, and probably was four or five months old. No other specifics as to the foods or foraging behavior of young in the wild seem to be available.

Foraging Behavior

According to Spitzer (1979), the sarus crane feeds at the Keoladeo Ghana Sanctuary in water no deeper than about 30.5 centimeters, probably because wading is relatively hard work, and sarus crane's dominance over smaller cranes such as the Siberian allows the sarus easier foraging opportunities elsewhere. At the upland edge of its foraging habitat in India the sarus crane also encounters the Eurasian crane. This latter species primarily feeds in cultivated fields and, furthermore, is somewhat smaller than the sarus, so it certainly poses no serious competitive threat to it. Although sarus cranes also sometimes field-feed, they do not do so in the large flocks that are characteristic of Eurasian cranes, but instead tend to forage in scattered pairs. Baker (1929) stated that the birds regularly feed in cultivated fields and open plains, as well as in water up to about 18 inches (45 centimeters) deep.

MIGRATIONS AND MOVEMENTS

Seasonal Movements

There are few, if any, seasonal movements of sarus cranes in India, where the birds are forced to migrate only in times of extreme drought (Walkinshaw, 1973). However, in Thailand there are apparently some seasonal movements, as Deignan (1945) stated that at Chiang Mai, the birds appear only during the colder nonbreeding period between December and March.

Certainly there must be occasional movements of vagrant birds; otherwise, one could not explain the development of an isolated population on Luzon Island, at least 700 miles from the nearest possible mainland range. More surprising is the recent establishment of a population in northern Australia, at least 3,000 miles from the species' probable present range limits in southeastern Asia. In spite of their large size and relatively heavy weight, the cranes are fully capable of extended soaring (Ali and Ripley, 1969), and so such occasional long-distance movements are certainly within the limits of possibility.

Daily Movements

According to Ali and Ripley (1969), short "commuting" flights are normally made each day between foraging areas and midday roosting places at the edges of rivers or jheels, with the birds flying only at about treetop height.

Walkinshaw (1973) reported that there are daily flights to and from roosting sites every morning and evening at Keoladeo Sanctuary. During the nonbreeding season some birds remained on the roosting ponds all day, while others flew out to nearby meadows, fields, and grain fields, although Walkinshaw did not estimate the flight distances involved.

GENERAL BIOLOGY

Sociality

The sarus crane seems to be relatively nonsocial. Although large flocks have on rare occasions been mentioned, such as groups of as many as 200 birds, this appears to be distinctly unusual (Walkinshaw, 1973). Rather, families and pairs seem to make up the social groupings of sarus cranes, even during the winter period. Walkinshaw reported on group sizes moving to and from roosting areas at the Keoladeo Sanctuary in September, just about at the start of nesting. Of 503 total groups, the most prevalent group size was of 2 birds (87 percent), while the next most common unit was of single birds (8.5 percent). The largest group he observed was of 9 birds, and the average group size was 2.02 birds. Only 13 of the groups (2 percent) were of 3 or 4 birds, suggesting that by this time of the year nearly all of the family groups had already broken up. Walkinshaw stated that the young birds remain with their parents for at least ten months, but after the breeding season begins they begin to assemble and roam the vicinity in groups.

Only a few days after Walkinshaw made the group counts summarized above, the monsoons began and the pairs dispersed for breeding. Before that time, he noted that foraging territories of the birds were well defined,

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with pairs occupying areas separated by as little as 100 feet and as much as 1,200 feet or more, averaging about 467 feet (142 meters). This would suggest an average foraging territory of about 1.6 hectares. Alternatively, 45 groups of cranes occupied an area of some 450 acres, providing a potential of about 10 acres (4 hectares) per foraging territory. As noted earlier, during the nesting season the breeding territories are much larger than this.

Daily Activities

Sarus cranes leave their nocturnal roosts shortly after daylight (Walkinshaw, 1973). On one occasion, when sunrise was at 7:07, the first of the birds to leave their roost departed at 6:49 and the last to leave departed at 7:50. About 80 percent of the birds that left the roost did so before sunrise. Walkinshaw noted that the birds left their roosts earlier than did the Siberian cranes and also began to call at a much earlier hour. However, when flying from the roost the birds tend to be silent. In the evening, after returning to the roost, sarus cranes once again become very noisy, as they also are in early morning hours.

During initial phases of roosting, pairs or individuals typically are dispersed from 3 to 100 meters away from other birds, but as darkness increases, they tend to move together toward an area of shallow water. After their early morning flights out for foraging, many of the birds return to the roosting area after about 10:00 a.m. for drinking. They then later return again to their foraging areas (Walkinshaw, 1973). In Australia, both the sarus and the Australian cranes feed periodically throughout the day, with intensive foraging occurring until midmorning, and again during late afternoon (Lavery and Blackman, 1969).

Interspecific Interactions

Walkinshaw (1973) reported finding the decapitated body of a young crane in an area where the day before he had seen a jackal (*Canis aureus*). He suggested that the presence of such predators is probably the major reason the birds normally roost in shallow water. In Australia the dingo (*Canis dingo*) and foxes (*Vulpes vulpes*) are known to feed on young birds, and red-backed sea eagles (*Haliastur indus*) are egg-predators (Lavery and Blackman, 1969).

As the largest of cranes, the sarus is easily able to dominate the much smaller Siberian crane, and it also dominates the Eurasian crane. Spitzer (1979) recounts seeing a pair of sarus cranes put to flight a flock of about 75 Eurasian cranes that landed within the feeding territory of the sarus pair; the sarus cranes drove off the Eurasian cranes simply by taking a few stiff-legged steps in their direction. However, Eurasian cranes and sarus cranes were sometimes observed roosting together.

These birds were occasionally even joined by a few Siberian cranes, suggesting that "safety in numbers" during roosting might outweigh any possible disadvantages of social interactions at that period.

Because of its very large size, the sarus probably dominates all other birds, and is unlikely to be a significant target of predation once the young are fledged. However, the Indian and southeast Asian population lives in close contact with humans and associated animals such as dogs, and probably these human-related influences are the greatest threat to the species.

BREEDING BIOLOGY

Age of Maturity and Time of Breeding

Walkinshaw (1973) reported that egg dates in India range from June to March. He found two records for India in June, probably six for July, eight for August, twelve for September, one for October, five for December, one for January, five for February, and three for March. There are Burmese records for March (one), August (two), and September (two), and a July record for Thailand. Walkinshaw also found a nest in northern Australia in January. In all areas, nesting is apparently stimulated by the onset of the wet season, with associated flooding and environmental changes that favor nesting at this period.

Among captive breedings, one pair of sarus bred initially when both members of the pair were 7 years old, while another pair bred initially when both members were at least 5 years old (private survey of Joe Blossom, pers. comm.). A pair of birds obtained by the Lesna u Gottwaldova Zoo of Czechoslovakia nested initially in 1966, when both members were 6 years old (Klika, 1974).

Pair Formation and Courtship

Dancing has been observed in the sarus crane both during the winter months and also during the breeding season. According to Walkinshaw (1973) dancing follows the typical pattern of the Australian crane, and lasts only a few minutes. The birds do not seem to whirl about when jumping. Instead, they tend to bound and bow directly up and down, although while on the ground they often run about in circles. In all cranes the functions of dancing are varied and often obscure. Dancing thus sometimes occurs as a displacement activity when the nest, eggs, or young are threatened.

Archibald (1975, 1976) states that this species resembles the Australian and white-naped cranes behaviorally. In all, the female begins the call, and during the introductory phase there is a short continuous call that is followed by a pause and then an extended series of

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sexually distinct calls. In the Indian race of the sarus crane the introductory note of the female is followed by a rapid series of short notes that transpose gradually into her regular series of calls, which average about two to three notes per note of the male. In the eastern race the female's calls are more highly pitched, and her notes are not given in synchrony with the regularly spaced notes of the male. In the males of both races, the introductory note is followed by an extended series of pulsed notes that average about a half-second in length, with the total duration of the display dependent upon the intensity of stimulation. Walkinshaw (1973) describes the female's unison call as a series of "tuk" notes, while that of the male is a loud, trumpeting *krrr* or *garrrooa*.

Posturing during the unison call consists of the female elevating her beak to or beyond the vertical between the horizontal and about 60 degrees above the horizontal for the remainder of the call, with her wings remaining folded and her neck extended vertically. The male extends his head and neck about 45 degrees beyond the vertical during the introductory note, and then elevates his humeri and lowers the wrists, exposing most of the wing to view. He remains in this posture for the rest of the display. The pair typically remains stationary and side by side for the entire display, with the male's raised wings sometimes touching the female's back (Archibald, 1975, 1976).

Walkinshaw (1973) observed copulation in a pair of sarus cranes about a week after the onset of their nest initiation but two days before he observed dancing in that pair. Initially, the birds were feeding about 300 yards apart and some 500 feet from their nest. The birds began to walk toward each other, then the female suddenly stopped, turned her back toward the male, and raised her head and neck, while pointing her bill forward and upward. The male hurried toward her, and as soon as he arrived, he stepped on her lowered back. Copulation lasted about 30 seconds, with the male slowly wing-beating during treading. He then hopped forward over the female's head.

Territoriality and Early Nesting Behavior

Walkinshaw's (1973) observations at the Keoladeo Ghana Sanctuary indicate that nesting may begin within a week after the start of the rainy season. He noted that the day after his arrival, September 1, the rains began, and 19 inches of rain occurred during the next three days. By September 7 the roosting marsh was flooded with 7 to 12 feet of water, and on September 8 the first territorial battles and nest-building were observed. He studied four separate pairs, each of which established territories ranging from 40.47 hectares (100 acres) to 60.7 hectares (150 acres) in area. In pair A, the first to begin nesting, the female worked adjacent to the

nest site, taking wads of debris and vegetation out of the water and piling them on the nest site with a lateral movement. The male stood about 15 feet from the nest, also extracting material from the water, and dropping it near the nest just beyond the female's reach. She initially worked 33 minutes on the nest, and her mate 25 minutes. Then they were interrupted by territorial invasion from a second pair. When the two pairs were only about 7 or 8 feet apart the males began false-preening furiously, with their respective mates immediately behind them and also preening. Then a third pair arrived, and was immediately attacked by the resident male. The situation returned to normal about 20 minutes later.

Two days later the nest was a huge pile of vegetation in the shallowest part of the marsh, where the water was about 12 to 18 inches deep. Both birds continued to pile material onto the nest, and the female twice sat down on it. This time they were interrupted by a fourth pair, which they met about 50 feet from their nest site. When the two pairs were about 9 feet apart, another intensive bout of "false preening" ensued. Pair A retreated to their nest, and were followed by the intruding pair. The latter actually climbed up on A's nest, and the female intruder began to tear it to pieces. This activity continued for about 75 minutes, during which time the male of the intruding pair stood guard, and the resident pair stood silently nearby. After the intruding pair returned to their own territory about 600 feet away, the resident female returned to her nest and began repairing the damage.

Judging from the size of one nest, Walkinshaw estimated that it must have been in use for years. It readily supported the weight of the bird, but nevertheless floated in the water of a sewer pond. Most nests that Walkinshaw saw rested on the mud beneath the water, while some were placed on higher sites where the water was quite shallow, and still others were among groups of dead stumps, adding support. The birds continued to add materials to the nest as long as the water levels rose. The average height above water to the nest rim was 17.36 centimeters (3.0 to 25.4), and the average water depth adjacent to the nests was 33.4 centimeters. Nine nests averaged 150.7×167.7 centimeters across at water level, and were narrower toward the top. They were constructed of available materials, including vegetation and various debris such as cattle dung.

Egg-laying and Incubation

Nearly always two eggs are laid, and according to some remarkably detailed observations on the species by the Mogul emperor Jahangir (reigning A.D. 1607-1627), the interval between the laying of the two eggs is 48 hours (Ali, 1927). The same authority gave the incubation period as 34 days, which agrees well with

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modern estimates of 31 to 36 days (Archibald, 1974).

Walkinshaw (1973) was able to find only four records of single-egg clutches and two for three-egg clutches among a total of 132 sets. Thus, the sarus seems to be remarkably consistent in laying two-egg clutches.

Although incubation is performed by both sexes, most incubation is done by the female, while the male tends to assume watch duties. Walkinshaw studied one pair in which the female remained on the nest all of one night, while the male roosted very near the nest in shallow water. The male went to the nest only five minutes after sunrise and a nest exchange occurred. About three hours later the female returned to the nest, while the male went off to feed. The female again left for feeding later in the morning and returned to incubate in early afternoon. Less than an hour later the male took over once again and incubated until nearly 4:00 p.m. The female then took over and remained on the nest through the night. In all, the male incubated for a total of about 7.5 hours during the 24-hour span, including three separate attentive periods.

Walkinshaw observed no distraction behavior at two areas where he watched incubation. However, while on a train he did observe the behavior of a nesting pair when men approached an active nest and picked up one of the eggs. Both members of the pair ran with outspread wings directly away from the men, although neither bird called. As the men returned to the train and it started away, the birds quickly returned to their nest.

In captive breeding attempts described by Klika (1974), the eggs of three different clutches were invariably laid about 70 hours apart, and in each of several years the nest was constructed in the same place. During two years of observation, the nest exchanges were performed very punctually. They typically occurred six times a day, between about 5:00 or 6:00 a.m. and late afternoon. The last one usually occurred about 7:00 p.m., and the female always brooded overnight, with the male standing several meters away.

Hatching and Postbreeding Biology

At the time of hatching the chicks are very weak, and may remain in the nest for as long as two days. However, even before they can readily walk they are good swimmers. By two days of age, they can walk well and swim very well. Both parents guard them continuously, feeding them and accompanying them. At the call of their parents, the young birds "freeze," and do not move again until the parents call once more. Within a few days the young are obtaining much of their own food. Walkinshaw believes that the birds seldom raise more than one young under natural conditions, although Kiracofe (1964) found that the young cranes that he raised in captivity were not aggressive toward one another.

Ali (1958) described how a newly hatched chick continued to fidget and cheep after a brooding adult sounded an alert call, a short, subdued, and staccato *kor-r-r* note. The adult then stalked back to the nest, gently pecked the chick, and repeated the note. At this the chick became silent and immobile. In another case, a pair leading another set of chicks uttered the same call and the chicks seemed to disappear as if by magic. One of the chicks was later discovered lying half submerged in a puddle at the base of a grass tussock, while the parents performed "broken-wing" distraction displays and alternated exciting trumpeting and the commanding *kor-r-r* notes.

Klika (1974) reported that during the first few days after hatching both parents held out food for their single chick, although by the second day the chick could feed independently. Its food consisted of a variety of insects, spiders, and worms that were offered by the adults. After the third day following hatching the duration of parental feeding lasted about 20 minutes.

There is no good detailed information on the timing of the molts in the species, although it is known that a flightless period does occur (Blaauw, 1897; Moody, 1932). In the pair of cranes studied by Klika, both members began to molt 9 days after the death of their 13-day-old chick, or about three weeks after its hatching date.

The fledging period of sarus cranes was estimated by Rothschild (1930) to be about three months. Walkinshaw (1973) believed that the young birds remained with their parents for at least ten months, or until the parents began breeding again.

RECRUITMENT RATES, POPULATION STATUS, AND CONSERVATION

Surprisingly little information is available on recruitment rates. Among a flock of 137 birds observed in Australia, 16.7 percent were young birds, suggesting a relatively high recruitment rate, approximately the same as that observed in Australian cranes (Blackman, 1971a). The apparent absence of migration, the prolonged breeding period, and the very large size of the adults and the associated effectiveness of parental protection perhaps all contribute to a seemingly rather high reproductive potential in this species.

EVOLUTIONARY RELATIONSHIPS

As indicated in the section on the Australian crane, the sarus and Australian cranes are very close relatives and probably can be considered to constitute a superspecies.