JOURNAL OF ECOLOGICAL SOCIETY

Vol. 16, 2003

Editor

Prakash Gole

Foreword

Editing the Sarus papers brought back vivid memories – of Sarus pairs and families and flocks and bands that roamed India's countryside – vast vistas of boundless cultivation, sponge-like wetlands and tall grasslands. Indeed to me Sarus portends well-watered landscapes, all that is green and golden in our country. But scientists and researchers who study and keep a track of these noble birds warn that such bounteous earth may become a thing of the past! As we waste soil and water in the pursuit of technological glories, Sarus will be increasingly removed from the parched landscape covered with bitumen, steel and concrete. Leaders and politicians want everyone to believe that technology and not nature is the solace of human beings. Where will Sarus go when all water is led through pipes and open soils converted to green houses producing genetically modified crops?

Nature lovers and conservationists may dream of bringing back old values of restraint and reverence towards nature, but they ill-fit the rampant consumerism that is slowly engulfing the countryside not only in India but also in neighbouring countries where Sarus still occurs. Authors whose articles appear in this journal have ably analysed the predicament of this crane. But reading through the paras one feels that it is extremely difficult to suggest conservation measures for a species which is as ubiquitous in its range as the habitats it uses – cultivation and wetlands! Perhaps a national land-use policy aiming to conserve species and habitat diversity may be the right answer. Overall landscape planning at regional levels that aims to reconcile human and wildlife interests can be visualised. These ideas, however, hardly look possible in the present scenario. But we need to campaign hard for just this.

Let us make Sarus the symbol of all that is desirable in our land and water scapes – healthy soils, varied vegetation, clean, sparkling streams and a benign earth that bodes well for human and non-human being alike!

Prakash Gole

Journal of Ecological Society

Editor
Prakash Gole

Photo credits
Indian Sarus : Gopi Sundar, International Crane Foundation, Prakash Gole
Eastern Sarus : J. A. Van der Ven

Published by
Prakash Gole, Director, Ecological Society, 1/B Abhimanshree Society, Pune 411008

Printed at
Aksharchhaya, 2035 Sadashiv Peth, Tilak Road, Pune 411030

Journal of Ecological Society Vol. 16 (2003)

Contents

Journal of Ecological Society Vol. 16 : 5-15 (2003)

A Review of the Three Subspecies of Sarus Cranes *Grus antigone*

G.W. Archibald[1], K.S. Gopi Sundar[1,2] and J. Barzen[1]

The tallest bird that flies is an evolutionary achievement awarded exclusively to the Sarus Crane *Grus antigone*. Standing at 1.5 - 2 meter, with a wing span to match, this enormous grey crane with bare red skin on the sides of its head that runs into the upper portion of the neck, is a bird of the subtropical regions of northern regions of the Indian subcontinent and tropical portions of southeast Asia and northeastern Australia (Meine and Archibald 1996, BirdLife International 2001). Today Sarus are confidently found in India, Nepal, Myanmar, Cambodia, Lao PDR, Vietnam and Australia. In recent times they were also found in Pakistan, Bangladesh, China, Thailand and the Philippines. The forces that led to their extirpation in these nations are now pressuring the surviving Sarus populations in all areas except Australia where there are fewer humans.

The Sarus Crane is one of 15 species within the crane family, Gruidae. It shares its genus with 9 other species among which its closest relatives are the look-alike Brolga *G. rubicunda* from Australia and New Guinea, and the White-naped Crane *G. vipio* from northeast Asia (Krajewski 1989, Krajewski and Fetzner 1994).

The historic range of the Sarus stretched from the lowlands of the Indus River in Pakistan, east across the upper portions of the lowlands of India, southeast though Myanmar, Cambodia and Vietnam and touching into China and Lao PDR. Until recently, Sarus were found on the northern lowlands of Luzon, the most northern island of the Philippine (McGregor 1909, Madsen 1981). Since the late 1960s they have been reported in northern Australia. Aboriginal folklore and genetic studies on fossil remains show that they have been in Australia well before the arrival of Europeans (Lavery and Blackman 1969, Schodde *et al*. 1988, Wood and Krajewski 1996). There are three recognized extant subspecies namely the Indian Sarus *G. a. antigone*, the Eastern Sarus *G. a. sharpii* and the Australian Sarus *G. a. gilli*. Population estimates for the three subspecies are 10,000, 1000, and 5,000 respectively for a world population of 15,000 - 20,000 birds.

Meine and Archibald (1996) provided the first comparative review of the three subspecies. Since, however, many ecological studies have been conducted on the Indian subspecies, and surveys and satellite telemetry on the Eastern subspecies have helped resolve information to a much finer scale than before. The Australian subspecies remains the least known. In this paper, we provide an updated review of the biology, distribution and status of the three subspecies. In this review we use a combination of published information, unpublished personal observations and understanding of the subspecies based on many years of fieldwork.

1. The Indian Sarus Crane *Grus antigone antigone*

Description

The Indian Sarus is the tallest and the heaviest of the three subspecies. The Indian Sarus has a white neck collar just beneath the red upper neck area, and white inner tertiary feathers that are elevated during display. The white tertiary feathers give the appear-

[1] International Crane Foundation, E-11376, Shady Lane Road, P.O. Box 447, Baraboo, Wisconsin – 53913, USA.
[2] Author for communication. Email : gopi@savingcranes.org.

ance of a bird with a white rump when the wings are closed. The white band on the neck can vary from a very small, narrow strip, to a large irregular shape that can be unequally large in the front or back of the neck (Plate 1). Its larger size and these white portions make the Indian Sarus a much more conspicuous bird than the Eastern and Australian Sarus that are a more uniform steel grey.

Distribution and movements

The Indian Sarus has a continuous distribution that does not vary seasonally (Sundar *et al.* 2000, Sundar and Choudhury 2003). The only discontinuity in the distribution range occurs in West Bengal and Assam where the Sarus are believed to migrate in winter, but the source of this population remains unknown (Choudhury 1998, Sundar *et al.* 2000). In other areas, seasonal movements are restricted and driven by availability of water. Large flocks of Sarus gather to roost along remaining wetlands and along the shores of lakes and rivers during the summer between April and July (Mukherjee *et al.* 1999). Over extended periods of time, flocks slowly build at dry season roosting and feeding areas, with birds rapidly dispersing in pairs and small flocks to their breeding territories with the arrival of the seasonal rains (monsoon) between July and October. In areas with year-round water supply, pairs can be perennially territorial (K.S.G. Sundar, personal observation). There are no records of regular, seasonal migrations in this subspecies.

General habits

The Indian Sarus Cranes are rarely found in forested areas and prefer widely open landscapes with a mosaic of wetlands and fields with wet crops (Sundar *et al.* 2000). Though habitat preference studies have not been conducted on the subspecies to date, information from surveys indicate that the Indian Sarus are increasingly being seen in crop fields, primarily rice paddies, in areas with extensive cultivation (Sundar and Choudhury 2003). In other areas that are dominated by wetlands, most of the Sarus seem to be using wetlands (see Sundar and Choudhury 2003 for details and references).

The Indian Sarus is an omnivore and a remarkably versatile bird in its foraging behavior. There have not been any feeding ecology studies, but anecdotal information based on casual observations indicates that the diet and feeding strategies are very diverse. They have the ability to hunt for small animal food (insects, fish, amphibians, reptiles, bird eggs and rodents), dig for the roots, tubers and bulbs of plants in both aquatic and upland habitats, strip seeds from grasses, and graze on fresh green vegetation (BirdLife International 2001). This enables the subspecies to survive in both wetland and upland areas throughout the year. Of major benefit to the Sarus until the advent of pesticides, was its ability to forage on a variety of food items in agricultural fields and in particular to eat waste grains in harvested fields during dry periods (Muralidharan 1983, Rana and Prakash in press). At Keoladeo National Park where Sarus and Siberian cranes were sympatric in winter, the Sarus fed in both uplands and wetlands while the Siberian Cranes were restricted to the wetlands.

Although human populations are high in many areas of the former range of the Sarus, the cranes and other wildlife that could adapt to a human-altered environment, flourished. In a few areas of India where traditional agricultural practices are maintained, Sarus cranes are abundant (Gole 1989, Sundar *et al.* 2000). One such area is the wetlands and agricultural lands in the districts of Etawah and Mainpuri in Uttar Pradesh, a region that is <5% of the range of the Indian Sarus but includes almost 3000 birds or 30% of the nation's crane population (Sundar 2003). This has remained unchanged at least for a decade (Gole 1989, Sundar 2003). In glaring contrast, in areas of India where modern agricultural practices have destroyed the wetlands and transformed the landscapes into monocultures dependent on advanced mechanization, the cranes have disappeared (Gole 1989, Sundar *et al.* 2000). Crops that have been particularly harmful to the habitats and breeding habits of the Sarus are soya bean and sugarcane. In other areas where cranes are revered, toxic chemical applied to seed grains to kill termites (Muralidharan 1983), and power lines with which cranes collide (Gole 1991, Sundar and Choudhury 2001), result in the deaths of many birds due to collision and/ or electrocution.

Breeding biology

The Indian Sarus typically nests during the monsoon season, although some nesting of pairs can occur in late winter (Suwal 1999, Vyas 1999, Mukherjee *et al.* 2002, Sundar and Choudhury 2003). The second nesting is thought to be of pairs that were unsuccessful in raising young during the monsoons. Indian Sarus use both flooded rice fields and natural wetlands to nest in. In areas with large marshlands, nests are characteristically spread out over the entire marsh (e.g. in the 29 km^2 Keoladeo National Park in Rajasthan; Ramachandran and Vijayan 1994). In areas with intensive cultivation, pairs prefer to nest in natural wetlands.

When wetlands are scarce and density of breeding pairs is high (e.g. as in Etawah and Mainpuri, Uttar Pradesh; Sundar and Choudhury, in preparation), simultaneously active nests can be as close as 25 m (Plate 2a). In areas where birds are not actively persecuted, pairs construct nests in wetlands as small as one ha. Nests can be as close as 37 m to human habitation, and as close as 4 m to metalled roads (Sundar and Choudhury in preparation). When extent of wetlands is very low in the landscape, pairs often nest in flooded paddy fields (Suwal 1999, Mukherjee *et al.* 2002, Sundar and Choudhury in preparation; Plate 2b).

Present status

At first appearance, the subspecies seems to be adept at adapting to changes in its habitat, food and nesting areas, but there is certainly a limit to its versatility. Except in the districts of Etawah and Mainpuri in Uttar Pradesh, the Indian Sarus appears to be declining everywhere else in their distribution range. There are some other districts in Uttar Pradesh that have wetland areas comparable to that found in Etawah and Mainpuri districts. However, until these areas are surveyed in detail to establish numbers of cranes and the existence of good habitat conditions for the cranes, the overall population of the subspecies can be described to be declining. The Indian Sarus is not hunted due to religious beliefs attributed to them. Changes in cropping from flooded rice paddies to dry sugarcane or soya bean, in association with deterioration of the wetland habitat appears to be the most important reason for decline since these remove both nesting habitat and food. An additional limiting factor appears to be reduced tolerance levels in farmers that have led to an increased mortality of eggs and chicks (Mukherjee *et al.* 2001).

2. The Eastern Sarus Crane *Grus antigone sharpii*

Description

Although large male Eastern Sarus stand almost as tall as the Indian Sarus, they are a much darker grey with only a slight tinge of lighter grey in a color where the bare red skin of the upper neck meets feathers (Plate 3). The Eastern Sarus Cranes are found in forested areas and nest in savannah-like habitats much more than any other species of crane, and its uniform grey colouring perhaps assists in making it less conspicuous to terrestrial predators.

Distribution and movements

There are two distinct populations of the Eastern Sarus Crane. The northern population is found in Myanmar and China. In Myanmar, the Sarus is concentrated in the Ayeyarwady and Bago divisions and the states of Kachin, Shan, Rakhine and Yangon (Latt 1998, 2002, 2003, Meine 1999,). In China, the Sarus are known to be very rare and the most recent report is from 1986 when a young Sarus Crane was captured from the Napahai Nature Reserve in western Yunnan province (Barzen and Seal 2000). Unconfirmed reports also exist from Yunxiang county in 1991 (Barzen and Seal 2000). In Southeast Asia, Sarus are found in Cambodia and Vietnam.

The movements of the cranes of the Myanmar population vary from being sedentary (as in the Ayeyarwady and the Rakhine), to birds that appear to have altitudinal migrations (as in Inlay and Daji, and rarely in the Rakhine; J. Barzen, unpublished information). These cranes behave like the Indian Sarus, nesting on natural wetlands and in wet agricultural fields during the monsoon season, and gathering at regions of available water during the dry season (Latt 1998, 2002, 2003 Meine 1999). However, the cranes that nest in north-western Cambodia have distinct migrations to wintering areas with distances ranging from 200-300 km (Barzen and Seal 2000, Barzen 2001a). Even here, it is possible that some birds are either entirely resident, or have seasonal movements over very small distances. Sarus Cranes that nest in the Ang Trapang Thmor (ATT; a large reservoir on a wide lowland basin west of the large lake, Tonle Sap in Cambodia that was improved and enlarged by the Khmer Rouge) for example, likely travel a maximum of 50-100 km during the winter, and only in response to drying up of the water in the reservoir (Barzen and Seal 2000, J. Barzen, unpublished information). This area is a mosaic of smaller wetlands and is good habitat for the Sarus Cranes when flooded.

Historically, records of the Sarus Crane can be found in the Plain of Reeds, a 62,500 km^2 depression in the Mekong River delta extending from Phnom Penh in Cambodia to near My Tho in Vietnam. This lies between the two populations that are presently clearly separated. Birds in the Plain of Reeds may have been largely sedentary, and the distribution range of the migratory population may well have overlapped with this population. This is similar to conditions that exist for the Whooping Crane *G. americana* and Sandhill Cranes *G. canadensis*.

General habits

Eastern Sarus Cranes are more comfortable in forested areas than other crane species nesting and wintering in open savannas (Barzen and Seal 2000, Barzen 2001b). This habit combined with their largely grey colouring may possibly be responsible for counts being lower than actual populations. The best-known dry season gathering area for Eastern Sarus in Cambodia are the wetlands associated with ATT which is unique in that it provides habitat for water birds during both the wet and the dry season (Barzen 2001b). In recent counts, 295 Sarus Cranes have been recorded at ATT during the dry seasons (Prentice 2002). In Vietnam, counts in recent years has shown that the best area for dry season flocks of the Sarus is Hon Chong in Kien Giang Province, where 378 cranes were counted (Triet and Hoa 2002). Both areas have vast areas with plants of the genera *Eleocharis*, the tubers of which are eaten by the Eastern Sarus Crane. Comparison of tuber size and quantity from wetlands that are perennial and those that experience a dry spell show that the tubers are more abundant and larger in wetlands that dry (J. Barzen, unpublished information).

Breeding biology

The biology of the Eastern Sarus on its nesting grounds has not been studied in detail. Eastern Sarus Crane in Cambodia and Lao PDR nest in wetlands in large dipterocarp forests (Plate 4). Birds of the Myanmar population have been seen to nest in natural wetlands of varying sizes with the minimum being <10 ha, and some birds have been recently seen building nests in flooded rice paddies in Myanmar (Latt 1998, Meine 1999). Historical records from the area hint at the ability of some pairs at least to nest in elevations as high as 3,500 m (J. Barzen, unpublished information). In Lao PDR, Sarus Cranes were reported to be nesting in recent years, but there is no detailed information on nesting habitat or breeding success (Barzen and Seal 2000).

Present status

Vast areas of the Mekong Delta in Vietnam and Cambodia once supported expanses of *Eleocharis* communities. In recent decades these areas have been reclaimed for agriculture and the cranes have retreated to a few remaining natural areas that have been protected. These include the Tram Chim National Park and the Hatien Grassland Reserve in Vietnam, and the shared Kampot wetlands of adjoining Cambodia and Vietnam, all of which provide dry season habitat for Eastern Sarus from November through April.

On the delta of the Ayeyarwady River in Myanmar, the Eastern Sarus Cranes usually nest in flooded rice fields where the construction of the nest uproots and destroys newly planted rice seedlings. In Myanmar, efforts by Buddhist monks have served to increase local respect for the cranes and many nests are protected. In other nearby areas like the Rakhine, Inlay and Daji, however, people destroy nests in crop fields. These people are angered more with the damage caused by trampling of the paddy by adult cranes rather than the loss incurred due to the construction of a nest using the paddy stalks (J. Barzen, personal observation).

The Eastern Sarus Crane is much less able to adapt to changing conditions compared to the Indian subspecies. Although numbers of the Eastern Sarus appear to be increasing, there are fears that a combination of wetland reclamation and permanent flooding may be diminishing the size of the communities of sedges upon which the cranes depend. Population viability analysis of the Eastern Sarus Crane in Tram Chin shows that this is a highly unstable population prone to extinction if current rates of environmental degradation and low breeding success of the cranes are not dealt with (Barzen and Seal 2000).

3. The Australian Sarus Crane *Grus antigone gilli*

Description

The Australian Sarus resembles but is slightly smaller and a bit lighter than the Eastern Sarus. The voice of the female during the unison call is quite aberrant from that of Indian and Eastern Sarus, an adaptation that might help reduce interbreeding with the closely-related and sympatric Brolga (Archibald 1976). The red on the neck does not extend as far down the neck as in the other subspecies (Plate 5).

Distribution and movements

Sarus were first reported in Australia by ornithologists in 1966 with the first breeding record about an year later (Gill 1969, Archibald and Swengel 1985, Bransbury 1991), when a few pairs appeared during the dry season (March through October) on agricultural fields near Normanton on the Gulf of Carpentaria in northern Australia. Their numbers increased annually and today there are several thousand. They were initially considered to be Eastern Sarus that has recently arrived from Indo China (Gill 1969, Lavery and

Blackman 1969). However, a comparison of their anatomy revealed them to be distinct (Shodde 1988). They were named *G. a. gilli,* after Mrs. H.B. Gill who first described Sarus in Australia (Gill 1969). The aboriginal people have a separate word for Sarus and Brolga. The Sarus are called the "brolga that dips its head in blood" referring to the greater area of bare red skin on the upper neck in the Sarus, or "the Brolga with red legs"; the true Brolgas have black legs (Lavery and Blackman 1969). Undoubtedly the Sarus has been in Australia for hundred if not thousands of years, yet had remained unnoticed among the more abundant Brolgas. DNA analyses indicate that the Sarus in Australia have been isolated for fewer than 37,500 years (Wood and Krajewski 1996). This time frame is consistent with Mayr's (1944) scenario for the origin of Australian-endemic avian fauna. Lowered sea levels supposedly created grasslands and marshy areas between islands of the Malay archipelago and provided a dispersal route for Southeast Asian birds into Australia via Timor (Mayr 1944, Wood and Krajewski 1996). Furthermore, geological evidence indicates that the last land bridges between the Malay islands and Borneo disappeared only 18,000 years ago (Morley and Flenley 1987) implying that the Sarus have had ample time to colonize Australia.

Within Australia, the Sarus are partly migratory (Marchant and Higgins 1993). In November with the onset of the rainy season, the Australian Sarus migrate from the Cape York peninsula northwest to the lowlands of the Gulf of Carpentaria where they breed during the wet season between December and February, a distance of c. 400 km (Meine and Archibald 1996).

General habits

No ecological studies have been conducted to understand the habits of the Australian Sarus Crane and available information is entirely anecdotal. They forage on insects, rodents, snakes and waste corn in the harvested fields and roost at night beside a reservoir and in natural wetlands. Like the Eastern Sarus in Cambodia and Vietnam, during the dry season the Brolgas gather in large flocks and congregate on dry coastal wetlands where they forage on the tubers of the "bulkuru" sedge or *E. dulcis.* The sympatric Brolgas are also known to have a very diverse diet, but have developed a seasonal preference for the sedges at least in Northern Australia (Marchant and Higgins 1993). In general, the Australian Sarus Cranes seem to have no known preference to foods in any season while Brolgas exhibit specialized feeding habits on an area with localized foods but can exist opportunistically on other food sources when conditions vary (see Harding 2001).

Breeding biology

The Australian Sarus Cranes are able to nest in wooded areas, and in areas with dense undergrowth (Figure 6). This is very different from the Brolga that are known to prefer only open and shallow wetland areas to nest in (Harding 2001). There have been no studies conducted, however, to identify limiting factors for breeding in Australian Sarus Cranes.

Present status

One theory suggests that before Europeans came to northern Australia there were more forests and brushy areas where cranes could not live. The introduction of tens of cattle and agricultural grain crops dramatically changed the landscapes of many regions of Queensland. In presettlement times, the Atherton Tableland was a tropical forest that was transformed to pastures and cornfields. Grazing on the savannas around the Gulf of Carpentaria undoubtedly made more habitat available for cranes. These anthropogenic changes in the landscape, perhaps resulted in an increase of the Sarus.

In 1984 and 1995, surveys of the nesting populations of Sarus in Australia and Brolgas were conducted on the Delta Downs cattle station on the lowlands of the Gulf of Carpentaria in 1984. Of 72 nests located, 48 were Sarus and 24 were Brolga (G.W. Archibald, unpublished information). It appeared that Sarus preferred more savanna-like wetlands and often nested in wooded areas (Plate 6), whereas Brolgas more frequently nested in wide-open wetlands. Both species answered the unison calls (a territorial threat display) of neighboring pairs irrespective of species and both species drove members of their own species and the other species from their nesting territories. Although through time restrictions in 1995, the territories of fewer breeding pairs were determined, the ratio of 2:1 Sarus: Brolga was maintained suggesting that an equilibrium had been reached between the two species in that area. It appears that the non-specialized habits of the Sarus in Australia are leading to the displacement of the Brolga, but there is no empirical evidence of this happening (G.W. Archibald, personal observations).

Other Sarus Cranes

The Sarus that inhabited Pakistan and Bangladesh, undoubtedly were the Indian Sarus. Those that once ranged into the tropical regions of southern Yunnan

Province, China, were undoubtedly the Eastern Sarus. But there is an unusual population of Sarus in north-west Burma near the border with India in the Rakhine state, that appears to be intermediate between the Indian and the Eastern Sarus as indicated by the size of the white collar and distinct white tertiary feathers. Perhaps it is a distinct subspecies, or perhaps there is a clinal change in the transition between the two subspecies. The first mention of this is in Blyth (1881), where Tegetmeier includes a letter by Col. Tickell. Col. Tickell, discussing the possibility of two separate forms of the Sarus in India, writes of T.C. Jerdon's descriptions of Sarus which is self explanatory: "… whitish-grey neck below the white auriculars, and no mention of the smooth nude pale orange collar intervening between the crimson papillous skin of the face and throat, and the feathered part of the neck. So if Jerdon mentions it correctly, he refers to a sarus different to any I have seen. Have we then *three* species in India?" Latt (2003) reports sighting of cranes in the Rakhine state, and photographs provided show Sarus Cranes with distinctly white tertiary feathers and white band on neck. These birds were seen foraging in a saline area close to mangroves (Latt 2003). Are these birds from an isolated population in north-east India that has seasonal movements into neighbouring Myanmar?

In the early half of the twentieth century, Sarus were native to the lowlands of northern Luzon of the Philippines. It was much smaller than the Eastern Sarus of the mainland and was suggested to be a distinct subspecies, *G. a. luzonica*. Several museum specimens confirm its small size. Cranes have not been reported in the wild since the early 1970s. Their former wetlands habitats have been converted to agricultural fields and towns. Unlike in India and parts of Myanmar where birds were protected due to religious beliefs, the Philippine subspecies was probably hunted to extinction.

Other historical information on distribution

The first two monographs on cranes provide information on distribution that is hard to confirm and understand, but is necessary to point out in this comparison of all the three subspecies of the Sarus Crane. The information in this section is compiled from Blyth (1881) and Blaauw (1897). Previously, only two forms of the Sarus were recognized; the Indian Sarus Crane (the present *G. a. antigone*, previously called "*G. torquata*" or "*G. collaris*"), and the Eastern Sarus Crane (described as *Ardea antigone* by Linnaeus. The Indian subspecies was differentiated from the Eastern Sarus as "larger and higher than the other, distinguished by its broad and pure white nuchal ring, and by its albescent almost pure white, tertiaries". Not many specimens were collected possibly due to the general opinion and respect accorded to their long-term pair bond. The differentiation was apparently first made by Blyth in a paper that could be accessed, but the results of which were present in his monograph (Blyth 1881) published posthumously by W.B.T. Tegetmeier.

Col. Tickell wrote several notes in response to the initial paper by Blyth differentiating two species of Sarus Cranes. These were included in the monograph. One line is of particular interest to the discussion that follows: "I have closely examined Sarruses dead and alive, in various parts of India – on the Nepal frontier, in Tirhoot, near Patna, Bhagulpoor, Rajmahal, near Sumbhulpoor (in modern day Bihar in India), also in Arakan and Tenasserim – and never met with an individual with a white collar". Tegetmeir also quotes a para from a book by T.C. Jerdon on the *G. collaris*, which is in stark contrast to Col. Tickell's information. Jerdon writes "the Sárás is found throughout the greater part of India and Burma, is rare south of the Godavery, and also apparently in the Pánjâb, …, but common in Central India, Bengal and parts of the north-west provinces and still more in the Candeish".

If Col. Tickell's assessment, pointing out specifically to the lack of white collar, was true, it appears that the Sarus in India was previously the Eastern subspecies. However, this may not be accurate since paintings of the Sarus from the late 16th or early 17th century shows the Sarus to have a white collar and tertiary feathers. The emphatic nature of Col. Tickell's dismissal of the presence of white collar and tertiary feathers in Sarus Cranes in India is inexplicable, particularly given his reputation as an observant and fastidious naturalist. Jerdon's paragraph on the Sarus was specifically for birds with the white band on the neck, and confirms information on Sarus Cranes as is presently known. Many of the areas mentioned by Col. Tickell to have Sarus Cranes no longer have Sarus populations, and are closer to the present distribution range of the Eastern subspecies. This region has cropping patterns that are conducive to the survival of the Sarus Cranes, similar to areas in Uttar Pradesh, Rajasthan and Gujarat where the Indian Sarus presently continues to survive. However, hunting pressures are very high. An interesting conundrum is whether the Sarus that was in Bihar and areas eastwards from here the Indian subspecies, and whether the cause for the disappearance was habitat modifi-

cation or hunting.

Another remark referring to the *G. collaris* in Blyth (1881) that is clearly in need of verification or substantiation concerns the distribution of the Sarus. In reference to the confusion in names and subspecies, Blyth writes "in the trans-Baikal countries the species (*G. collaris*) is *G. leucauchen* of Temminck ...". We have been unable to obtain any other reference to the presence of the Sarus from the "trans-Baikal" region except for Walkinshaw's (1973) mention of fossil records from "Europe". The lack of specific sites and very broad nature of information on distribution makes it very difficult to ascertain locations of historical presence. If the distribution of the Sarus did extend to the area near and around Lake Baikal, they must have needed to migrate at least short distances for the winter. There should be references of these migrations in non-English languages of the area. Considering the rich folklore of the people of the region, there should be substantial mention/ use of the Sarus in traditional folklore, poetry and/ or art if they carried out migrations in the area, or even if they were resident.

A related casual statement that does not bear a correlation with contemporary information is the possibility that the presence of the Sarus in Australia was recognized earlier. Blyth (1881) writes "… in Australia, the *G. australis* is the *antigone* of the older catalogues". Whether this was a *faux pas* by Blyth remains to be verified.

Epilogue

Concerted research efforts to understand the biology and requirements of the Indian and Eastern Sarus Cranes have been driven by the necessity to conserve them and their habitats. In Australia, interest on the Sarus has been little owing to the apparent increase in the population. However, the information that presently exists is sufficient to indicate that the three subspecies exhibit widely differing behaviours at least with respect to seasonal movements and breeding biology. However, all three subspecies, though capable of using upland areas for foraging require wetland areas to breed, are limited by the deterioration that these habitats face in their distribution range. As demonstrated in India, Myamnar and Australia, within certain constraints the adaptable Sarus can flourish in areas where human populations are high and/or where humans have altered the landscape to the accidental benefit of the cranes. However, the cranes have their limits of tolerance. If wetland habitats that are vital for breeding and wintering are altered, the cranes will move elsewhere. Power lines and poisons applied to newly planted grain will kill cranes just as effectively as guns and snares. Man knows what he can do and cannot do to live in harmony with these enormous and inspiring birds. Let us hope that through the enlightened actions of man, Sarus can one day return to areas of their wide range from which they have disappeared because of humans.

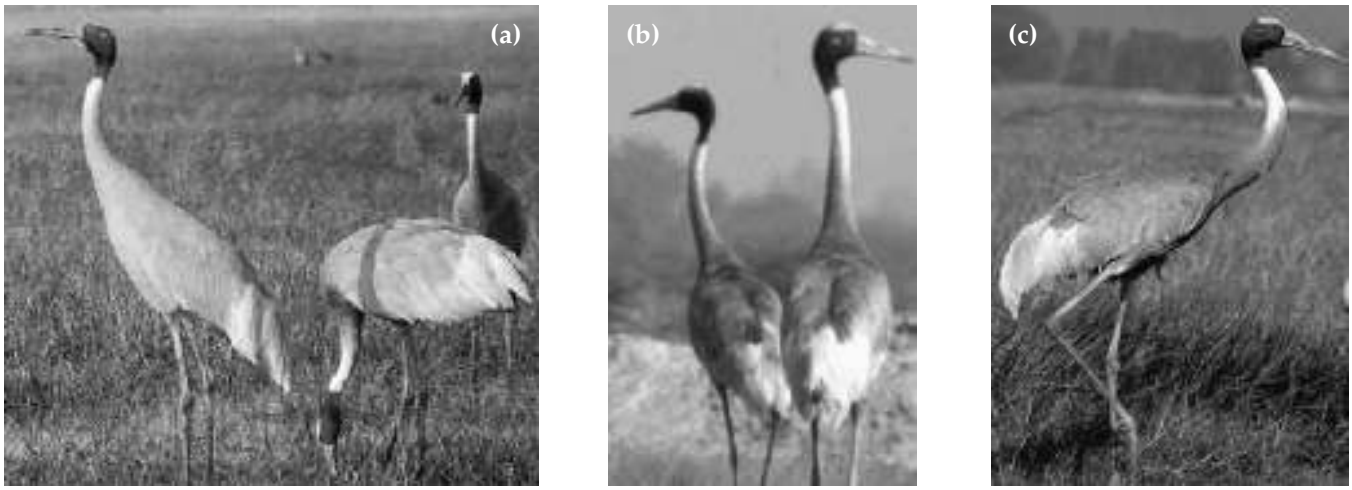


Plate 1 : Variation in the amount of white on neck in the Indian subspecies of Sarus Crane G. a. antigone. (a) Adult male (left) and female (middle, feeding), and adult of indeterminate sex (right). Note variation in the amount of white on neck, and lesser amount of white on male. (b) Adult pair; female (left) with lesser amount of white, and male (right) with more white on collar. Note also for male how the white marking is more on the front of the neck than the back. (c) Adult male with white marking more on the back of the neck than the front. © K. S. Gopi Sundar. All pictures were taken in Uttar Pradesh.

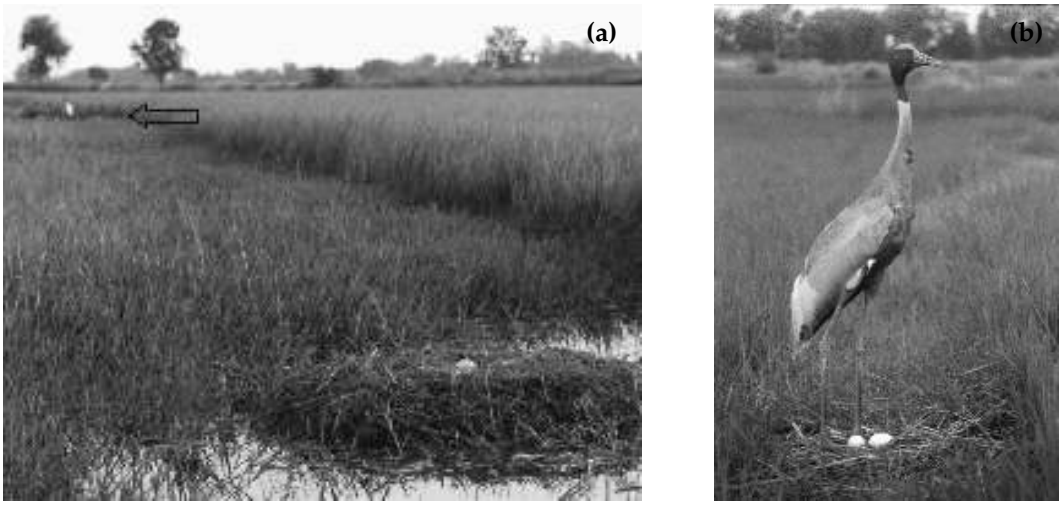


Plate 2 : Breeding habitat and nest structure of the Indian Sarus Crane. (a) Picture showing two simultaneously active nests of Indian Sarus Cranes in natural marshlands (low vegetation and flooded area) in the midst of rice paddies (taller vegetation). Pair on far side is seen reinforcing their nest (position indicated by arrow). Note openness of habitat. (b) A nest in the middle of a paddy field constructed entirely out of paddy stalks. © K. S. Gopi Sundar. All pictures taken in Uttar Pradesh.

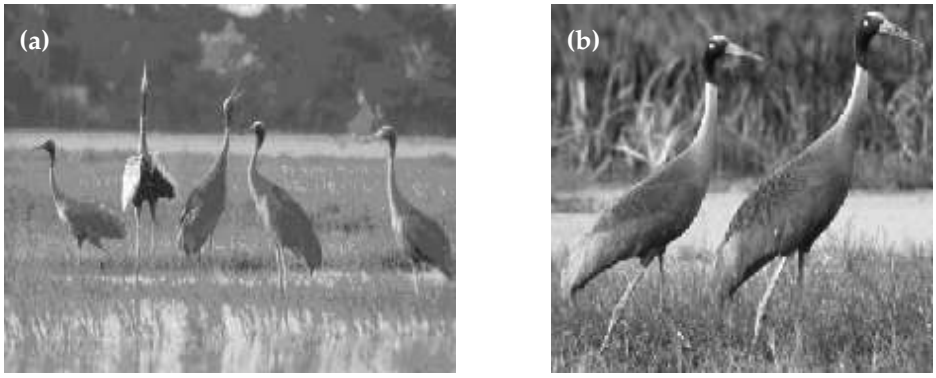


Plate 3 : Eastern Sarus Cranes from the two known populations. (a) Four Sarus Cranes from a non-breeding flock of the China-Myanmar population photographed in the Ayeyarwady Delta, Myanmar. Note colouring on the neck present as grayish-white markings, and almost entirely absent on tertiary feathers when wings closed giving the birds a overall appearance of uniform gray. (b) Pair of Sarus Cranes from the south-east Asia population photographed in the Preah Vihear Province, Cambnodia. Note how white on both neck and on the tertiary feathers are present as an indistinct markings. © Eleanor Briggs.

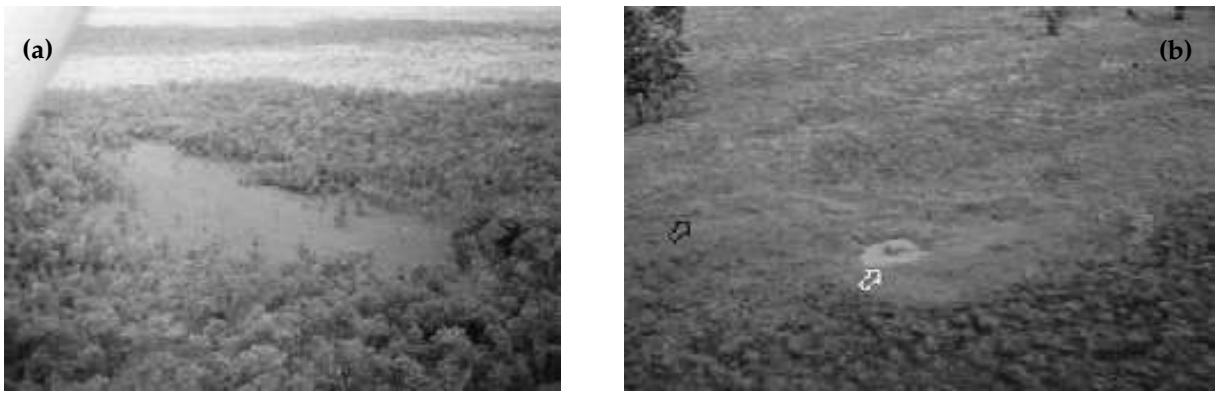


Plate 4 : Aerial pictures of Eastern Sarus Crane breeding habitat and nest in north-east Cambodia. (a) Typical breeding habitat showing dipterocarp forest and open wetland areas. (b) Picture of an Eastern Sarus Crane nest (white arrow) and adult bird (black arrow) taken from 100 m altitude. Note proximity to wooded area (top left corner). © J. Barzen.

Plate 5 : Pictures of Australian Sarus Crane showing much reduced white on body. (a) Pair unison calling. Note how the tertiary feathers are marked with very light white on the outer edges (in male on left) preventing the appearance of a bird with a white rump when wings are closed (female on right). (b) Adult male showing grayish markings on neck. Note how red skin on head extends to a much shorter extent in comparison with the other two subspecies. © G. W. Archibald.

Plate 6 : Breeding habitat and nest structure of Australian Sarus Crane. (a) Nest in typical nesting habitat. Note proximity to trees. (b) Pair at nest with one chick hatched. Note dense undergrowth and proximity to trees (in the background).

Acknowledgements

We thank Mr. Prakash Gole for inviting the paper for the special issue of the Journal of the Ecological Society on Sarus Cranes. The paper was written using the extensive bibliography of the Ron Sauey Memorial Library, International Crane Foundation and we thank Betsy Didrickson for her ready help with literature and obtaining photographs. KSGS was supported at ICF through grants by the International Crane Foundation and the United States Fish & Wildlife Services and thanks L. Dando, D. Ferguson and J. Harris for facilitating travel and stay at the International Crane Foundation during the writing of this paper. We thank Daw Latt for allowing the use of her photograph of the cranes in the Rakhine. A previous draft of the paper benefited from the comments of B. Didrickson and we thank her for her assistance.

References

Archibald, G.W. 1976. Crane taxonomy as revealed by the unison calls. In: Proceedings of the International Crane Workshop, Oklahoma State Publishing and Printing Department. Pp. 225-251.

Archibald, G.W. and Swengel, S.R. 1987. Comparative ecology and behavior of eastern sarus cranes and brolgas in Australia. In: Lewis, J.C. (ed.). Proceedings 1985 Crane Workshop. Platte River Whoop-

ing Crane Habitat Maintenance Trust and U.S. Fish and Wildlife Service, Grand Island, Nebraska. Pp. 107-16.

Barzen, J. 1994. ICF team discovers rare wildlife in Cambodia. *ICF Bugle* 20(4): 3.

Barzen, J. 2001a. Waterbirds and wetlands of northern Cambodia.
http://www.savingcranes.org/Travel/ESCR.asp. Accessed: Nov 10, 2003.

Barzen, J. 2001b. Waterbirds and wetlands of northern Cambodia. *ICF-Bugle* 27(4): 1-2.

Barzen, J. and Seal, U.S. 2000. Eastern Sarus Crane PHVA final report. CBSG, Apple Valley, MN.

BirdLife International 2001. Sarus Crane *Grus antigone*. In: Threatened Birds of Asia: the BirdLife International Red Data Book. BirdLife International, Cambridge, UK. Pp. 1118-1150.

Bransbury, J. 1991. The Brolga in south-eastern South Australia: a report on a study conducted during 1989-1990. South Australian Department of Environment and Planning, Adelaide.

Gill, H.B. 1969. The first record of the Sarus Crane in Australia. *Emu* 69: 49-52.

Gole, P. 1989. The status and ecological requirements of Sarus Crane. Phase I. Report submitted to the Ministry of Environment and Forests, Government of India.

Gole, P. 1991. Welfare of the tallest flying bird in the world. *J. Ecol. Soc.* 4: 29-42.

Harding, C. 2001. Use of remote sensing and Geographic Information Systems to predict suitable breeding habitat for the Brolga in south-western Victoria. Unpublished B.Sc. Honours thesis, Centre for Environmental Management, University of Ballarat, Australia. 127 pp.

Krajewski, C. 1989. Phylogenetic relationships among cranes (Gruiformes: Gruidae) based on DNA hybridization. *Auk* 106: 603-618.

Krajewski, C. and Fetzner, J.W. Jr. 1994. Phylogeny of cranes (Gruiformes: Gruidae) based on cytochrome-b DNA sequences. *Auk* 111: 351-365.

Latt, T.N. 1998. A report on a survey of breeding Sarus Crane (*Grus antigone*) distribution in Myanmar. Unpublished report submitted to the International Crane Foundation, October 1998.

Latt, T.N. 2002. Observations on Eastern Sarus Crane status and structure in the Ayeyarwady Delta, Myanmar. Unpublished report submitted to The Oriental Bird Club, UK. 55 pp.

Latt, T.N. 2003. Records of the Sarus Crane (*Grus antigone*) status and brief study of other bird species in Rakhine state, Myanmar. Unpublished report submitted to the Oriental Bird Club, UK. 113 pp.

Lavery, H.J. and Blackman, J.G. 1969. The cranes of Australia. Advisory Leaflet No. 995, Division of Plant Industry, Department of Primary Industries. 8 pp.

McGregor, R.C. 1909. A manual of Philippine birds. Manila Bur. Printing, Manila, Philippines. 769 pp.

Madsen, K.K. 1981. Search for the Eastern Sarus Crane on Luzon, Phillipines. In: Lewis, J.C. and Masatomi, H. (eds.) Crane research around the world: proceedings of the International symposium at Sapporo, Japan in 1980 and papers from the World Working group on Cranes, International Council for Bird Preservation. Pp. 216-218.

Marchant, S. and Higgins, P.J. (eds.) 1993. Handbook of Australian, New Zealand & Antarctic Birds. Vol. 2 – Raptors to lapwings. Oxford University Press, Melbourne.

Mayr, E. 1944. Timor and the colonization of Australia by birds. *Emu* 46: 113-130.

Meine, C.D. 1999. Summary report on a survey of breeding Sarus Cranes (*Grus antigone*) in Myanmar. Unpublished report submitted to the International Crane Foundation, prepared in cooperation with the Myanmar Forestry Department and the Wildlife Conservation Society – Myanmar. 33 pp.

Meine, C.D. and Archibald, G.W. 1996. The cranes:- Status survey and conservation action plan. IUCN, Gland, Switzerland and Cambridge, UK. 294 pp.

Morley, R.J. and Flenley, J.R. 1987. Late Cainozoic vegetational and environmental changes in the Malay Archipelago. In: Whitmore, T.C. (ed.) Biogeographical evolution of the Malay Archipelago. Clarendon Press, Oxford. Pp. 50-59.

Mukherjee, A., Soni, V.C., Borad, C.K. and Parasharya, B.M. 1999. Diurnal use of reservoirs by the Indian Sarus Crane (*Grus antigone*) during summer months. *Zoos' Print Journal* 14(7): 72-74.

Mukherjee, A., Borad, C.K. and Parasharya, B.M. 2002. Breeding performance of the Indian sarus crane in the agricultural landscape of western India. *Biol. Cons*. 105: 263-269.

Muralidharan, S .1993. Aldrin poisoning of Sarus cranes (*Grus antigone*) and a few granivorous birds in Keoladeo National Park, Bharatpur, India. *Ecotoxicology* 2: 196-202.

Prentice, C. 2002. Sarus Crane Census at Ang Trapeang Thmor, Banteay Meanchey Province, Cambodia. Unpublished report submitted to the International Crane Foundation. 4 pp.

Rana, G., and Prakash, V. in press. Unusually high mortality of cranes in adjoining areas of Keoladeo National Park, Bharatpur, Rajasthan. *J. Bombay Natl. Hist. Soc.*

Schodde, R., Blackman, J.G. and Haffenden, A.T. 1988. New subspecies of Australian birds. *Canberra Bird Notes* 13: 1.

Sundar, K.S.G. 2003. Using road transects to monitor abundance, demography and habitat use of Sarus Crane *Grus antigone*: A case study from Etawah and Mainpuri districts, Uttar Pradesh. Unpublished report submitted to the International Crane Foundation. 18pp.

Sundar, K.S.G. and Choudhury, B.C. 2001. A note on Sarus Crane *Grus antigone* mortality due to collision with high-tension power lines. *J. Bombay Natl. Hist. Soc.* 98: 108-110.

Sundar, K.S.G. and Choudhury, B.C. 2003. The Indian Sarus Crane *Grus a. antigone*: A literature review. *J. Ecol. Soc.* (this issue).

Sundar, K.S.G., Kaur, J. and Choudhury, B.C. 2000. Distribution, demography and conservation status of the Indian Sarus Crane (*Grus antigone antigone*) in India. *J. Bombay Natl. Hist. Soc.* 97: 319-339.

Suwal, R.N. 1999. Studies on the habitat preference, movements, nesting and population dynamics of Sarus Cranes in Lumbini. M.Sc. Thesis, Tribhuvan University, Kirthipur, Nepal.

Triet, T. 1999. The Eastern Sarus Crane (*Grus antigone sharpii*). Population Viability Analysis. Unpublished report submitted to Land Resources, IES, University of Wisconsin, Madison. 25 pp.

Triet, T. and Hoa, N.P.B. 2002. Sarus crane counts in Vietnam. 28 February – 03 March, 2002. Unpublished report submitted to the International Crane Foundation. 7 pp.

Vyas, R. 1999. Breeding success and chick mortality in Sarus Cranes. *Newsletter for Birdwatchers* 39(1): 5-7.

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

Wood, T.C. and Krajewski, C. 1996. Mitochondrial sequence variation among the subspecies of Sarus Crane (*Grus antigone*). *Auk* 113: 655-663.

❑

Journal of Ecological Society Vol. 16 : 16-41 (2003)

The Indian Sarus Crane *Grus a. antigone*: A Literature Review

K. S. Gopi Sundar[1] and B. C. Choudhury[2]

Introduction

When Gole (1989) conducted a literature search on the biology of the Indian Sarus Crane *Grus antigone antigone*, he found "precious little of it". Since, however, a spate of scientific papers in journals, theses, reports (published and otherwise), newsletter articles, popular science articles and newspaper features has covered various aspects of Sarus Crane biology. This increase in attention is largely driven by the need to have information to assist in applied conservation. However, there are no recent reviews of the species that provide a critique of this information. In this review, we bring together all known information on Sarus Cranes and provide an update of the biology of the species. All references to Sarus Cranes in this paper refer to the nominate subspecies unless mentioned otherwise.

There is a wealth of information on Sarus Cranes present in grey literature, including unpublished reports, and non-peer-reviewed papers. This review combines both peer-reviewed papers available from standard reference services, and other literature known to have information on Sarus Cranes. Literature for this review was accessed through the bibliographic services of the Ron Sauey Memorial Library at the International Crane Foundation (ICF), bibliographies (Pittie 2001) and references in reviews (Walkinshaw 1973, Johnsgard 1983, Allan 1996, Meine and Archibald 1996, BirdLife International 2001). One of us (KSGS) obtained original papers, theses and reports from the libraries of WII and ICF to prepare this review. In addition, several people contributed reports, theses, newspaper clippings, unpublished manuscripts, and personal observations, and kindly allowed their use for this review.

This review is divided into two major portions. In the first portion we use information from the literature to illustrate biases in regional coverage, aspects of ecology covered so far, the irregular rate of publications, and the evolution as it were of scientific and popular attention on Sarus Cranes. In the second portion, we provide a summarized account of Sarus Crane distribution, status, population and ecology. The summary is intended to add to the information in previous reports, particularly the detailed distribution account in BirdLife International (2001). Also, information otherwise scattered as anecdotal records and observations have been used to provide a comprehensive review of specific aspects.

We used books, major reports, scientific papers from major national and international journals, journals with smaller distribution (*Journal of the Ecological Society*, *Pavo*, *Zoos' Print Journal*), newsletters (*Cheetal*, *ICF-Bugle*, *Newsletter for Birdwatchers*, *WWF-India Quarterly* etc.), theses, proceedings, popular science articles in major magazines (*Down To Earth*, *Hornbill*, *India Today*, *Sanctuary Asia*, *Science Today*), and other miscellaneous publications published before October 2003. Distinction of short communications follows that used

[1] Author for communication. Present address: Exchange Visitor, International Crane Foundation, E-11376, Shady Lane Road, P.O. Box 447, Baraboo, WI – 53913, U.S.A. Email: gopi@savingcranes.org.

[2] Head, Endangered Species Management Department, Wildlife Institute of India, P.B. 18, Chandrabani, Dehradun – 248 001, Uttaranchal, India. Email: bcc@wii.gov.in.

by the journals referred to. Reviews of the family Gruidae have been avoided in the analyses unless they are specific to cranes of India and have new information. The smallest geographic unit considered is the state, and ecological papers are divided into five major categories (breeding biology, surveys/ distributions/ status reports/ field methods, popular science/ general accounts, other aspects of ecology including feeding, crop damage, etc., and miscellaneous subjects). This information is meant to cater to a general audience and statistical treatment of the data is avoided. In addition to a numerical account, we explore in brief the history of work on the Sarus and its relevance to contemporary Sarus biologists, particularly those with a conservation focus, in India. Critique of information here is entirely impersonal and academic in nature. This is meant to help focus attention on aspects that require attention and to assist in planning future work to be of better use to applied conservation.

I. An analysis of Sarus Crane literature

What's in a name : taxonomy and common names

In taxonomy, the Sarus underwent a dizzying change of names, the history of which is not very clear. Most of the following discussion is based on Blyth (1881) and Blaauw (1897). The first reference to the species in taxonomic literature was in *"Briss. Ornith."* where it is referred to as *G. orientalus indica.* Blyth (1881) considered the two known forms as distinct species. Linnaeus' description of the Sarus in his *Systema Naturae* in 1766 as *Ardea antigone* appears to be of specimens of the eastern subspecies, and possibly did not see any specimens/skins of the Indian subspecies until later. Buffon possibly first closely observed the Indian subspecies in 1780, when he called it *"la Grue à collier"* based on the white collar that is still used to differentiate subspecies. The species appears to have first gotten the specific name *collaris* in 1783 by Boddaert. A work of taxonomy (*"Gm. Syst. Nat."*) published in 1788 refers to the species as *Ardea antigone* (or *Grus torquata*). Another very different name followed in 1831 when Franklin called it *Grus orientalis.* Sykes reinstated it as *G. antigone* in 1832, but Gray lists it again as *G. torquata* in 1844. In 1854, it was designated *Antigone antigone.* Blyth (1881) originally describes it as *G. torquata,* but in his book (published posthumously), it is classified as *G. collaris* following Buffon. Sharpe also reverted to *G. collaris* in 1894, which is the name that Blaauw (1897) uses. Sharpe (1894, 1899) placed the Sarus and the Brolga under the same genera Grus. Much later, taxonomists recognized only one species of the Sarus Crane with two forms/subspecies (Dubois 1904, Peter 1934).

The formal description of the Sarus as *Ardea antigone* (Linnaeus in 1760) was clearly the Eastern subspecies, and earlier accounts refer to the subspecies as "the Greater Indian Crane" (1743), and *"la Grue des Indes Orientales"* (in 1760). Vieille named it *Grus antigone* in 1817, and the name shifted to *Antigone antigone* in 1854. The work of Sharpe (1894, 1899), Dubois and Peter (1934) places the Sarus firmly under the genera *Grus,* which was followed by Blaauw (1897). What is puzzling is how the Indian subspecies came about to be the nominate subspecies, even though the eastern race was first named *"antigone".*

"Antigone", the specific epithet, was a female character in Greek philosophy, famous as the rebellious daughter of Oedipus, and the etymology of the word is "in place of a mother," from *anti* "opposite, in place of" + *gone* "womb, childbirth, generation" (www.etymonline.com). The reason for the choice of the name for the Sarus is unclear and may be present in previous literature that we did not have access to.

The term "Sarus" seems to have a Sanskrit origin from the term *"sārāsa",* which is translated variously as "pertaining to lake, water", "anything fluid", "sheet of water", and "pond". In Tamil, the word relates to dance. Either way, the preferred habitat or the behaviour of the cranes was chosen for the common name and persisted. Jerdon and Tickell (in letters quoted in Blyth 1881) spelt the common name as "sarrus". The pronunciation and spelling changed to the presumed original "Sárás" until Blyth (1881), but later authors resorted to "Sarrus", "Sáras" or "Saras", and most used "Sarus", which continues to be used today. The name also seems to have traveled because this was also the common name for the eastern subspecies in Myanmar ("Burma"), Vietnam and other northeastern Asian countries.

Fossils identified as Sarus Cranes in Europe are found in Pleistocene deposits (Walkinshaw 1973). Krajewski (1990) and Krajewski and Fetzner (1994) have suggested that the Gruinae species, under which the Sarus are placed, arose in the late Miocene or early Pliocene. Analyses of fossil records show that the subfamily Gruinae diverged from the Balearicines (Crowned Cranes) 10-20 million years ago (mya), that species within Gruinae diverged some 1-3 mya, and subspecies became differentiated 0.5-1.5 mya (Krajewski 1990, Krajewski and Fetzner 1994, Krajewski and Wood 1995). Sarus Cranes have had an uncontroversial placement in the classification of Gruidae irre-

spective of the method used (calls : Archibald's 1976; DNA : Krajewski 1989). Archibald (1976) had initially suggested that the Brolgas *G. rubicundus* and the Sarus were very closely related species. Subsequent DNA analyses have shown that while the sequences of the other two species in the Sarus Crane species group (Sarus, Brolgas and the White-naped *G. vipio*) formed a clade, the Sarus was monophyletic (Krajewski and Wood 1995). Within the Sarus Crane subspecies, classification based on morphology distinguishes three separate subspecies, but recent phylogenetic analysis showed that there is little variation in the phylogeographic structure of the haplotypes and microsatellites of the three subspecies suggesting there has been no long-term geographic isolation of these populations (Wood and Krajewski 1996, Jones 2003). Preliminary calculations indicate that the common ancestors of all Sarus Crane haplotypes existed less than 420,000 years ago, and the Australian population has been isolated as recently as 37,500 years ago (Wood and Krajewski 1996). Molecular studies using microsatellites show that the Sarus in India have two high frequency private alleles indicating reduced gene flow between India and other populations (Jones 2003). Although birds of different populations show a divergence, analysis of individual genotypes showed a clinal nature to the variation with the Indian Sarus and the Eastern Sarus representing two ends of the cline (Jones 2003).

Literature review : chronology and developments

A total of 147 published works that were not early taxonomic treatises were researched. Of these, 21 contained information that was repeated in earlier works, or were published subsequently as papers. In addition, over 30 regional bird lists, unpublished manuscripts, and proceeding papers were consulted. Most publications were articles in larger national and international journals, smaller journals or newsletters (57%), and included eight theses, eight reports and 11 popular science articles in magazines (Figure 1). The earliest reviews of the Sarus appeared in monographs of cranes (Blyth 1881, Blaauw 1897), and ecological information in regional annotated checklists of birds (Jerdon 1864, Hume and Marshall 1879, Murray 1890, Baker 1928a,b). A surge of information occurred during 1870-80 due to the publication of the first ornithological journal in the Indian subcontinent in 1872-3, *Stray Feathers,* and most were anecdotal or descriptive information on the distribution and/or observations in the field of the habits of the Sarus as part of regional avifaunal lists (Hume 1872-3, Adam 1872-3, Ball 1874, Butler 1876, Oates 1877, Hume and Davidson 1878, Reid 1881). A major event that allowed people to write information pertaining specifically to the Sarus Crane, was the founding of the Bombay Natural History Society, and more importantly the publication of its journal. The first published works focusing entirely on the Sarus were notes on breeding biology in the *Journal, Bombay Natural History Society* (JBNHS; Barnes 1887, Bulkley 1893, O'Brien 1909, Mosse 1910, Pershouse 1911, Hill 1930). The beginning of the journal *Pavo* also initiated authors, and the first paper in this journal on the Sarus concerned the feathering on the head of the Sarus (Menon *et al.* 1980). Another surge in numbers of publications followed in 1980-2000, on the heels of Gole's (1989) authoritative survey report on the ecological requirements of the Sarus in India. The survey, and associated activities such as the founding of the Indian Working Group on Cranes (Anon 1989), and popular science writings served to accelerate interest in the conservation of the Sarus and its habits. This period coincides with the writing of the first world review of the status and conservation requirements of cranes (Archibald *et al.* 1981). In this review, the authors hope "the 1980s will be a decade unparalleled in crane research and conservation" (Archibald *et al.* 1981). At least for the Sarus, this hope appears to have been true.

Literature review: aspects studied and regional coverage

Observations of behaviour, particularly breeding and behaviour pertaining to pair-bond, have been present beginning from the diary of the Emperor Jahangir in the 16-17th century (see Ali 1927), and repeats in almost every work that has some details on the habits of the species. Hume and Marshal's (1879) book also presented information on egg dimensions from eggs in the wild, which was novel considering that taxonomic literature previously only presented morphological measurements of bird specimens. Walkinshaw (1964) seems to be the first person to present a paper to an international audience devoted entirely to the Sarus' biology, and followed this up with many new observations on breeding biology, food habits and behaviour of the Sarus in his classic book (Walkinshaw 1973). For over a decade, this book was the sole source of information on Sarus breeding and behaviour, until the publication of Gole's (1989, 1991) reports and papers on the requirements of the Sarus in India. Figure 2 shows the rate of publications of Sarus Crane biology (literature before 1950 includes general accounts of birds of a region due to an absence of specific literature on the Sarus, while those after-

wards include publications pertaining almost entirely to the Sarus). Most papers post-1900 were published in the JBNHS (35%) and the *Newsletter for Birdwatchers* (15%).

Parasharya *et al.* (1986) conducted the first field investigation using ecological methods and explored the extent of damage Sarus Cranes caused in paddy crops in Gujarat. Other papers, which detailed observations on aspects of Sarus biology from the Keoladeo National Park in Rajasthan, followed soon afterwards (Gole 1991, Ramachandran and Vijayan 1994). The first thesis on the Sarus Crane was based on observations of a single captive bird (Desai 1980), and the first thesis on wild birds was regarding the breeding biology of a pair in the Aligarh Muslim University campus (Iqubal 1992). The first major thesis on Sarus Cranes included multiple aspects of the Sarus' biology with intensive field observations in Gujarat (Mukherjee 1999).

Researchers in Gujarat have continued to work extensively, and much of the published information today comes from that state (Figure 3). It is expected that this state will continue to lead Sarus Crane research, though attention on the Sarus has increased considerably in Rajasthan, Uttar Pradesh and Maharashtra. Work in Rajasthan comes primarily from Kota and Bharatpur, and there is considerable scope to increase our understanding of the birds in this state by expanding over a larger area and including additional aspects of biology. Some studies have been initiated in Nepal and Pakistan as well. Madhya Pradesh and Haryana are very important states for the Sarus, particularly as much of the landscape is deteriorating (see Sundar *et al.* 2000). However, research on the Sarus from these states is very minimal and need to be strengthened.

Status surveys dominate the literature on Sarus Cranes today (39%, Figure 4). Of the literature that contain one aspect of Sarus ecology explored in detail, studies on breeding biology dominate (45%). Much of the information on Sarus Crane breeding success is provided as rates of recruitment (% of young counted) using data from rapid surveys. The first paper on breeding success of Sarus Cranes was a compilation of many years of observation on nests and chicks with pairs along canals in Kota (Vyas 1999a), and field studies designed specifically to understand various aspects of breeding biology were first carried out in Gujarat (Mukherjee *et al.* 2000, 2001a,b), and more recently in Uttar Pradesh (Sundar and Choudhury 2003, Sundar in press).

The first reference to deterioration of wetland habitat and how this may affect the Sarus and other wetland birds in India occurred in the late nineteenth century (Reid 1881). His words, which describe the drought of 1877-8 in the Lucknow division in Uttar Pradesh, are worth quoting here: "There are still, fortunately, many of these natural reservoirs where birds are plentiful in the (winter) season; but if the cultivation of the singhara nut (water chestnut) becomes as general as it is now in certain localities, a diminution in the number and variety of their aquatic tenants will assuredly follow" (Reid 1881, pp. 499). Conservation-oriented crane studies began in earnest after the global review (Archibald *et al.* 1981), and more seriously on the Sarus Crane after the all-India survey by Gole (1989, 1990). This gained momentum with several state level surveys being carried out to determine conservation status (Vyas 1999b, Tatu 2001).

A much larger and more coordinated effort began with the Sarus Crane project of the Wildlife Institute of India, which began with an all-India survey (Sundar *et al.* 1999, 2000), and ended with over two years of concerted fieldwork on various aspects of Sarus biology in Rajasthan and Uttar Pradesh. Preliminary field observations of this project have been communicated in popular science articles (Choudhury and Sundar 2001, Sundar 2001, 2002a,b, Kaur and Choudhury 2002), and the final report and other papers are presently near completion. Another key feature of the project was the first coordinated all-India Sarus Crane Count, which helped to bring interested people together on a common platform and paved the way for a long-term monitoring programme (Choudhury *et al.* 1999, Sundar *et al.* 2000b, Kaur *et al.* 2002). This also served to reactivate and reorganize the Working Group on Cranes, which has since been renamed Indian Cranes and Wetlands Working Group (ICWWG) to allow coverage of a broader range of issues over a longer time frame. Presently, the Sarus Crane is categorized as "globally threatened", and future efforts are expected to be directed at understanding the requirements of the species to assist in practical, field conservation of habitat and crane populations.

II. An update on the Indian Sarus Crane

Mythology and history

The earliest mention of the Sarus is in the Ramayana written in the third century BC. There were many interpretations of the species of birds that Valimiki wrote of as krouncha in the verse :

| ma nishada prathishtaam twamagama shashwathi samaaha |

|| yeth krouncha mithuna dhekham ava dehi kama mohitam ||

They were represented variously as flamingoes, swans, even doves. The identity was confirmed recently as being the Sarus Crane (Leslie 1998). The other well-known classical literature known to mention the Sarus is the diary of the Moghul emperor Jehangir, written in the late 16th or early 17th century. The Emperor also encouraged art related to wildlife and had his court painter painted a pair of Sarus Cranes (Ali 1927). While the reference in the *Ramayana* was more romantic and poetic in its being, Jehangir's writings were natural history and behavioural ecology. Subsequently, Buddhist scriptures talk about an incident of a Sarus Crane hunting observed by Gautam Buddha in Lumbini. The Sarus is thus firmly entrenched in Hindu mythology and Indian culture. Sarus have been accurately represented in a painting in the National Museum at Amsterdam in a de Hondecoeters (1636-95) work named "Het drijvend vveertje" (Blaauw 1897). Sarus have also been represented in a series of 121 bird paintings by Lady Elizabeth Gwillim (1763-1807) housed at McGill University, Canada (Subramanya 1994). We have not, however, been able to provide a comprehensive account of paintings of Sarus Cranes, and this should be a very interesting topic to cover, particularly the variation in form and representation of the birds depending on the background of the artist.

The earliest detailed writings on the behaviour and breeding of the Sarus Crane are the observations of the Emperor Jehangir dating from the early 17th century (Ali 1927). Ali (1927) recounts in detail the Emperor's fascination for the Sarus, particularly its apparent lifelong pair bond. Of particular detail are his descriptions on territoriality, pair bond and nidification. Territorial interactions between a semi-domesticated pair he maintained on his palace grounds, and a wild pair from the surrounding area speaks of an early understanding into the ways of the Sarus Cranes. His writings on how a Sarus was predated, and the subsequent death of its mate "pining" demonstrate that the now widespread belief of lifelong pair bond in the Sarus Cranes was prevalent from as early as the 17th century. The Emperor was also perhaps the first person to identify individual cranes by placing gold rings on their noses and legs (see Ali 1927).

Folklore

The Sarus Crane likely owes its continued existence in the Indian landscape to the myths and legends that abound relating to the presumed long pair bond of the birds (Chaturvedi 1992, see also Hasan 1996). There are no comprehensive accounts of how Sarus Cranes are represented in the culture in various states. In Gujarat, it is apparently still a custom in many areas for newly married couples to be taken out to see a pair of Sarus Cranes, the sighting of which is thought to be auspicious to the wedding. This is the most common folklore associated with the Sarus in India throughout its distribution range in India. Most people believe that the pair bond between paired cranes is permanent, and the death of one will invariably cause the other to die of grief or starvation. It is also common for the farming community to regard nesting of the Sarus in their fields as a sign of good fortune in many areas. Farmers in Uttar Pradesh, particularly Etawah and Mainpuri, regard the Sarus as a watchdog for crops, and use crane alarm calls in the night to warn intruders that may damage crops (e.g. Nilgai, cattle or other humans), particularly during the harvest (K.S.G. Sundar, personal observation). Eggs of the Sarus are believed to have medicinal properties in few areas in Gujarat and thought to cure eye diseases and for cattle with stomach ailments (J. Kaur, personal communication). Folklore regarding the Sarus is certainly more extensive than illustrated here, and will prove to be an interesting subject for study considering the care some people are known to bestow on injured crane chicks (e.g. Rai and Bhadwar 1989). It is likely that many more stories are written on the Sarus and its association with man, but these are either in regional languages and not accessed by us, or not documented in any of the libraries/reference lists we have used (e.g. Didrickson, in preparation).

In Rajasthan people were never known to worship the cranes, although they have traditionally discouraged killing of a single bird of a pair (Adam 1872-3). Many folk songs in Rajasthan frequently mention Sarus Cranes (Kulshreshtha and Vyas 1989). On the other hand, recent accounts of hunting of the Sarus Crane are present from Rajasthan (Thapa and Parihar 1998). In Nepal, they are revered due to the predominance of Buddhism in the country, so much so that recent conservation efforts have weaved a strong religious message to conserve habitat for breeding Sarus Cranes (Shreshtha 1995, Suwal 1995, Beilfuss and Suwal 1999).

In Pakistan, Sarus Cranes are reportedly mentioned in poetry (D. Ferguson, in litt., 2003). However, there has also been a long tradition of crane hunting in many parts (primarily Common, *G. grus* and Demoiselle cranes, *Anthropoides virgo;* Roberts 1977), and hunting of Sarus Cranes in recent years has been reported (Ali 1993, A. Khan, in litt. 2003).

Distribution and status

A detailed description of distribution can be found in BirdLife International (2001). Records indicated here are those that have not been presented before in earlier reviews of the subject, or for areas where changes in status have occurred sufficiently enough to warrant mention.

Outside India, Nepal is the only other country with >100 individuals of Sarus Cranes, and where studies have been conducted on this subspecies. They are present in small numbers, very localized, restricted to five locations, and largely concentrated in the districts of Rupandehi and Kapilvastu with a total population of <150 individuals (Suwal and Shreshtha 1992a,b, Shreshtha 1996). In Nepal, habitat deterioration is believed to be the major cause for the decline of the birds. The only exception seems to be the Lumbini Crane Sanctuary where habitat restoration and maintenance is proving to be beneficial for increased breeding success of Sarus Cranes (Beilfuss and Suwal 1999, R.N. Suwal, personal communication; see also Suwal 1999 a,b for a detailed treatment of records and information in Nepal).

The Sarus was thought to be extinct in Pakistan until recently. Few pairs have been repeatedly sighted close to the Indian border in Nagarparker, at the western fringe of the Thar Desert (Ali 1993, Ahmad 1995a) and of 7-14 birds from the Rann of Kutch region (Khurshid and Munaf 1994). Breeding records in recent years are from the same area (Ahmad 1995b). However, hunting and habitat deterioration are thought to be severe (Ali 1993, Khurshid and Munaf 1994), and the Sarus is thought to be a casual visitor in the Sindh along the Indo-Pakistan border (A. Khan in litt., 2003). Sarus Cranes are probably extinct in Bangladesh and we could not find any recent records except for a pair seen in Thakurgaon, and one shot in north-east Bangladesh (Thompson *et al*. 1993). Thompson *et al*. (1993) describes the status of the species in Bangladesh as "former resident?". Very few records of this subspecies are found from Myanmar (e.g. Hopwood 1912).

In India, the present extent of distribution is from Jammu in the north, through Nepal, to Chandrapur in Maharashtra in the south, and from Gujarat in the west to Assam in the east (Choudhury 1998, Choudhury 1990, Choudhury 2002, Choudhury *et al*. 1999, Sundar 1999, Sundar *et al.* 2000a,b, Kaur *et al*. 2002). Information from crane counts indicate that the distribution is contiguous for most of the distribution range, the only exceptions being the cranes in Maharashtra and Assam, which seem isolated (Choudhury *et al*. 1999, Sundar *et al*. 2000a, Kaur *et al*. 2002; see Figure 5). Most Sarus are concentrated in the western fringe of the Gangetic flood plains continuing westwards into Rajasthan and Gujarat (Figure 5). A study in 1988-89 presented information that suggested a decline in the distribution range (Gole 1989), and this information was adopted by reviews of the species since (Meine and Archibald 1996). However, countrywide studies conducted afterwards showed that the present distribution range of the Sarus Crane is reduced from its historic range, but not to the extent that was surmised (Choudhury *et al*. 1999, Sundar *et al*. 2000a,b, Kaur *et al*. 2002). Also, previous reviews thought that distribution of the Sarus varied with season, but recent surveys, both countrywide and local, indicate that though there is seasonal migration from dry areas, Sarus Cranes are mostly resident and distribution range remains nearly the same throughout the year (Mukherjee 1999, Sundar *et al*. 2000a,b). Much of the Sarus populations are found outside the protected area network of the country (Figure 6), with small populations in sanctuaries and national parks in the country (Table 1).

In recent years, Sarus have been seen regularly at Pong Dam, near Dharamsala at an altitude of 7,000 ft in the lower Himalayas and other areas in Himachal Pradesh (Hingston 1920, Singh 2003, J.W. den Besten, personal communication). The Sarus was known to be rare in the state, but recent observations indicate that the distribution and abundance are more than previously known (Singh 2003, J.W. den Besten, personal communication). It is likely that the spread of rice cultivation along even the smaller rivers in the state have provided sufficient habitat for the species to breed and increase in number.

Anecdotal information provides adequate evidence of the disappearance or reduction of crane numbers considerably from few areas. There are no records to indicate that they were ever common in the Punjab (see Blyth 1881). Singh (1993) mentions the Sarus in the checklist of birds of the state, but this is not substantiated by authenticated sightings recently. Another state that the Sarus seems to have disappeared as a common bird, and being seen largely as a straggler in recent years, is West Bengal. Sarus were apparently present in low numbers in Jalpaiguri, Barrackpore and Manbhum (Beavan 1868), in the open valleys of Sirguja (Ball 1874), and a rare winter visitor in Darbhanga (Inglis 1902). Recently, the only record has been a stray pair recorded in Koochbihar district (Sundar *et al*. 2000b).

In Maharashtra, the few records of the Sarus from the Bombay area are Symons' (1909) records. He saw one pair in 1897 at Salsette, one more bird in 1910 in the same area, and one bird in Bandra. The Sarus was apparently breeding in the region in the past; egg collection records from the collection of the British Museum of Natural History list eggs from Dwaraka, Bombay collected in September 1878 (in Walkinshaw 1973, pp. 211). In recent years, records in Maharashtra are from the eastern district of Chadrapur, where habitat deterioration and loss of protection from farmers are thought to have reduced populations to a few pairs today (R. Job, personal communication). Recently, however, conservation efforts in this region have concentrated on nest protection and resulted in successful breeding after many decades, and a detailed Sarus survey is presently underway (R. Job, personal communication).

The Sarus seems to have reduced more quickly from northern Uttar Pradesh, particularly from the districts of Lakhimpur-Kheri and Pilibhit. Gole (1989) estimated over 1,500 birds in both these districts, but information during recent surveys indicate that numbers presently are well below this estimate (Sundar *et al*. 2000b). Another state with a reduction of Sarus numbers is Haryana due to repeated years of drought and intensified agriculture practices, but lack of detailed information across years prevents an empirical comparison. At least from Sultanpur National Park in Jhajjar, numbers seem to have reduced from tens of birds in the early nineties to a pair in 1998 (Sundar *et al*. 2000).

In northeast India, the Sarus Crane is a rare and occasional visitor to Assam (Baker 1899, Choudhury 1998, 2002). Though recorded by Ali and Ripley (1980) to be resident, hunting and habitat deterioration are thought to have decimated breeding populations in recent years (Bhattacharjee and Saikia 1990, Choudhury 1990). Manipur was thought to hold populations previously, but recent surveys/counts indicate uncertain reports (Sundar *et al*. 2000b), or have been unable to locate the species (Choudhury 1990, 2002). This portion of the distribution range of the Sarus is of great interest since the ranges of the Indian and the eastern subspecies converge, even overlap, here (J. Barzen personal communication). Detailed surveys and genetic studies of birds found in these areas are required to understand the extent of overlap and if there is cross-breeding of the subspecies.

Population and relative abundance

The only population estimates have been that of Gole (1989) who applied the line-transect method for road counts during a survey that covered nearly the entire distribution range of the species. He estimated a total of 12,000-15,000 Sarus Cranes in India. An index of crane numbers (encounter rates) has been calculated for various districts in another countrywide survey (Sundar *et al.* 2000a), but a comparison of these two studies is not possible due to differing field and analytical methods. Additional information is available from Gujarat; encounter rates of 0.68 Sarus/ km and 0.28 - 0.37 Sarus/ km were recorded in Kheda and Thasra tehsils (Parasharya *et al.* 1989), and density of breeding pairs varied seasonally between 0.11-0.25 pairs/km^2 (Mukherjee 1999). In Nepal, Suwal (1999a,b) reported an encounter rate of 0.9 cranes/km and a density of 0.6 Sarus/km^2, and estimated a population of 292 cranes for Rupandehi district.

Based on information of declines in wetland areas in the country and anecdotal information on Sarus mortality, the present population estimate of this subspecies is thought to be 8,000-10,000 birds (Meine and Archibald 1996). Empirical evidence of the decline of the Sarus is available from the Keoladeo National Park in Bharatpur, Rajasthan (258 in 1983 to 43 in 2003; Kumar, K., personal communication), and from Madhav National Park, Madhya Pradesh (50 birds in 1987 to none in 1990; Saxena 1990). There is, however, no information on changes, if any, outside protected areas where most of the Sarus population is found. Based on a large number of anecdotal reports with qualitative references to population levels, one estimate suspects that the decline of the Sarus has been serious and drastic, and that present numbers are perhaps "at best 10% and very probably 5% or even 2.5% of its numbers in 1850" (BirdLife International 2001). We strongly feel that there are no reliable population estimates for the Sarus Cranes in India after the initial attempt by Gole (1991), and this lacuna need to be urgently looked into.

Regular counts using pre-determined roads as transects can be an appropriate method to monitor Sarus Crane numbers along road sides, particularly if the population is resident and breeding pairs are perennially territorial. Roads have been so far used to study Sarus Cranes with limited results, and there is a need to standardize a method to estimate and monitor populations. Sundar (2003) describes in detail three years of counts in the Etawah-Mainpuri region, and shows how repeated counts in pre-determined areas can help to collect and maintain information on various aspects of Sarus ecology by carrying out regular road transects, in addition to determining variations in

crane numbers. Regional counts managed by local organizations that can maintain information, is an efficient manner using this count as a model.

Demography: rate of recruitment

Demographic parameters available for Sarus Cranes are principally derived from surveys (Table 2). The proportion of young in the population is an important parameter that indicates the rate of recruitment and the extent of breeding success in a particular year. Surveys use total counts of juveniles with young seen and did not distinguish adults in flocks based on lighter colour of the head. One study (Mukherjee *et al.* 2002) used the number of young birds in flocks in the dry seasons. Comparison between these two methods in the same area (Kheda, Gujarat) in 1998 showed a difference in the values obtained (survey: 8%; congregation count: 11.04%). This suggests the need for standardizing the method for calculation of this important parameter and that data presently available may be used only as a rough indication of recruitment. Overall, average values show a healthy rate of recruitment of 14.6%, which is comparable with values available for the Sandhill Cranes, *G. canadansis* and is higher in comparison to some other species (Allan 1996). Values for other species of cranes have been derived by counting young during fall migration or at wintering grounds (see Allan 1996 for a critique of methods and caveats of data obtained in migration grounds or flocks). This method may not be useful in resident species as some families may not join flocks, and juveniles may depart from territories at different ages. There are few studies of productivity based on monitoring of individual pairs and their young. Such studies can be instituted with ease for the resident Sarus Cranes and the data obtained will be far more useful and reliable than surveys and counts at flocks.

Demography: Proportion of successful pairs and incidence of pairs with two chicks

Proportion of pairs successful in raising young was as high as 48% in Kheda in 1998 and as low as 12% in the Etawah-Mainpuri region (Table 2). Numbers of pairs monitored and field techniques used varied, and this could bias these data making them difficult to compare directly. The range of values, however, falls within the known range for other species of cranes in the world, which have information from the post-breeding season (Allan 1996). Proportion of successful pairs with two young varied widely between areas and years. Time of survey is an important consideration, and conducting surveys/counts at a time when most juveniles have not yet departed from territories will provide the most accurate estimates. Counting immediately after fledging will provide the most accurate measures since dispersal of young in resident cranes are usually related to the female laying the subsequent clutch (Nesbitt *et al.* 2002), and crane young are visible in the landscape. In India, January/February is the best time to conduct counts to ascertain these parameters. Studies to calculate errors inherent in counts/surveys conducted at different times of the year due to departure of juveniles from the territory are required. Some workers use pairs observed in flocks to calculate the proportion of breeding birds in the population. Recent long-term studies on common cranes have shown that sibling bonds between juveniles of the same brood can last for up to three years of age (Nowald *et al.* 1996). During calculations of demographic parameters from count data, pairs in flocks should not, therefore, be considered as breeding pairs.

Habitat use

Habitat use information is available for the Sarus Crane principally from Rajasthan and Gujarat (Table 3). Most of these studies were conducted at a comparable time period, but data are presented as use by total number of birds counted, and very few studies have information for habitat use by groups (pairs/families/flocks). Analyzing data differently can have very differing results (Table 3). For example, counting a pair, a family with one chick, and one flock with 65 birds give a total of 70 individual birds, but only three groups. Flocks are characteristically rare compared to pairs or families of Sarus Cranes, but number of birds in flocks account for most of the population. Using number of groups, it would appear that wetlands are underutilized. This occurs since the few flocks use principally wetlands. The data, therefore, shows very high use of wetland habitats if numbers of individuals are considered. To avoid problems inherent in such analyses, it is important to represent information separately for individual birds and groups (e.g. Gole 1989, Mukherjee 1999, Sundar 2003).

In areas with large wetland tracts, Sarus used more wetlands (e.g. Vyas 1999a, Latt 2002), and in areas where agriculture dominated, they used more crop fields (see Table 3 for references). Information on seasonal changes in habitat use is available from only one area in Gujarat and shows that habitat use varied with season (Mukherjee 1999). There have been no preference studies to date and are required to determine if habitat changes in the landscape has changed

the habits of the Sarus, which was previously thought to be a wetland specialist.

Breeding biology: nesting and nidification

Sarus Cranes breeding biology does not vary across their entire distribution range with regard to nesting habitat and behaviour (Ali 1958, Ali and Ripley 1980, Breeden and Breeden 1982, Gole 1987, Iqubal 1992, Ramachandran and Vijayan 1994, Suwal 1993, 1999, Mukherjee *et al.* 2000, 2002, Sundar and Choudhury 2003, Sundar in press). Pre-nesting mating behaviour has been described by Mukherjee (2002). For nesting, Sarus Cranes use the material immediately around the nest site piling vegetation into a roughly round heap of vegetation surrounded by a narrow moat (Lowther 1944, Breeden and Breeden 1982, Gole 1987, Ramachandran and Vijayan 1994, Mukherjee 1999). In a mosaic landscape, the Sarus prefer natural wetlands as nesting habitats, though they are known to use flooded paddy fields extensively for nesting (Parasharya 1998, Suwal 1993, 1999a, Mukherjee *et al.* 2000, Borad *et al.* 2001a). In areas with human habitation, Sarus built nests at an average of 410 m away from houses (Rupandehi district in Nepal; Suwal 1999a), but were as close as 37 m in India (Etawah-Mainpuri districts; Sundar, K.S.G. and Choudhury, B.C., in preparation). These differences likely reflect varying disturbance levels experienced by nesting pairs. Sarus Cranes are known to keep their nests clean of fecal matter during incubation, and of eggshells post-hatching (Sundar and Choudhury 2003). In recent years, reduction in wetland habitats for Sarus Cranes is believed to force them to nest in paddy fields, thus destroying considerable amount of the standing crop (Borad *et al.* 2001a). This is believed to be a major factor in reducing public sympathy for the Sarus in agriculture-dominated landscapes, and is believed to reduce breeding success due to increased egg and chick mortality caused by farmers in whose fields the Sarus nest in (Parasharya *et al.* 1996, Mukherjee *et al.* 2002). There is a growing amount of literature on breeding biology in general, but few that relate landscape quality to breeding density and success. This is important considering that changes in land use in India is occurring at a landscape level and specific information can assist in planning landscapes for Sarus conservation.

The breeding cycle of the Sarus Crane is known to be bimodal in some areas in Rajasthan with a principal nesting season during the monsoon when most pairs nest and a minor season after the winter with few cranes nesting (Kulshreshtha and Vyas 1989, Ramachandran and Vijayan 1994). Considering all anecdotal accounts, bimodal nesting was widely prevalent before the 1930s, with records of nesting during the minor season from Madhya Pradesh ("Saugor" District, King 1911; Paraswara; D'Abreau 1935), and Gujarat (in January in Mahikantha; O'Brien (1909) as well. Nesting was recorded practically throughout the year (Table 4). Previous authors have suggested that the nests in the smaller post-winter season are by pairs with egg/chick loss during the regular breeding season. The reasons for this behaviour to persist in Rajasthan are being investigated (J. Kaur, personal communication). Studies post-1930s have been more intensive and indicate that in recent years the nesting season of the Sarus ends in early or mid-October and the minor season is restricted to February-April (Table 4). Changes in rainfall patterns, associated changes in available habitat, and deterioration of nesting habitats have likely caused this reduction in the nesting period.

We found very little information on the incubation period of the Sarus Crane in the wild (Table 5). Using available information, the average incubation period in wild and captive birds is 33 and 34 days respectively (Table 5). These data are from one or two nests, and there are no studies that provide descriptions of incubation period from an area on multiple nests and years.

Renesting by Sarus pairs with unsuccessful first clutches has been recorded from captive birds for a very long time (Conway 1965), and is now known to be a common phenomenon (Ellis *et al.* 1996). In the wild, Mukherjee (1999) provided the first evidence of renesting in the Sarus. There are no studies, however, to document if renesting is advantageous, and whether renests vary from first nests in terms of egg size, survival, location of nest etc. Though captive propagation is relied upon to reinstate wild populations in endangered cranes, studies in captivity have shown that fertility is often low, and the process is very expensive and labour intensive (Conway 1965, Ellis *et al.* 1996, M. Putnam, ICF-Curator of Birds, personal communication). In India, we require field studies to provide the usefulness of second clutches in the wild to ensure that collecting eggs will not affect crane populations negatively. Also, it may be impractical to rely on captive propagation to refurbish deteriorating wild populations.

Breeding biology : clutch size and breeding success

Very few studies on breeding biology have been carried out, and principally in Rajasthan and Gujarat

(Table 5). Clutch size and breeding success seems to be relatively similar across areas and years. Analytical methods to represent information need to be standardized since studies provide success as different measures that are not comparable (Table 5). There was no difference in nest success of nests in different habitats (Mukherjee *et al.* 2002). Continuing work has made it possible to document breeding success of Sarus Cranes since 1992 in Bharatpur's Keoladeo National Park (Ramachandra and Vijayan 1994, S. Sharma personal communication, G. Rana and V. Prakash personal communication, Kaur, J. and Choudhury, B.C., in preparation), and it is of vital importance to continue this effort. In all the areas, breeding success was limited by human disturbance (50% in Nepal; Suwal 1999a), though natural causes such as flooding and predation by crows were also documented. Predation is largely on eggs by crows (Ramachandran and Vijayan 1994) and possibly by jackals (Mukherjee *et al.* 2002).

Very little published information is available on chick mortality. An instance of a young chick taken by marsh harriers is known (Kaur, J. personal communication). A possible case of cronism is reported, but the author was uncertain if it was an adult scavenging on a dead chick (Xavier 1995). Chick mortality was the most during the pre-fledged stage (Vyas 1999). No information is available of rates of post-fledging and post-dispersal mortality of young birds. Rates and factors affecting mortality of birds after dispersal are important aspects and an understanding of these is required to institute safeguards during the breeding season.

Movement and social structure

In dry areas, Sarus have regular daily movements to and from wetland roost sites (Walkinshaw 1973, Ramachandran and Vijayan 1994). Seasonally, however, cranes seem to flock away from nesting territories in reservoirs etc., particularly in drier months (Mukherjee *et al.* 1999). Suwal (1999a) documented daily movement of different pairs and found that pairs within protected, perennial wetlands moved much less compared to pairs outside such areas. Cranes also tended to have more restricted movements during the breeding season. In areas without perennial water supply, cranes are thought to migrate locally, though there is no evidence and/or indication of the distance travelled by cranes in these situations. In West Bengal and Himachal Pradesh, for example, Sarus are seen only seasonally, and there is no information on the source of these populations. Satellite telemetry studies are required to understand these movement patterns.

In most places, Sarus Cranes seem to have a breeding population consisting of territorial pairs and a non-breeding population in dynamic flocks. During surveys, Sarus are characteristically seen as pairs or families, and few flocks (Gole 1991a,b, Vyas 1999a,b, Sundar *et al.* 2000). Flocks are known from almost the entire distribution range (Table 6). The biggest flocks occur during dry years or months in Rajasthan and Gujarat (Breeden and Breeden 1982, Banerjee and Gopakumar 1986, Mukherjee *et al.* 1999), while some areas in Uttar Pradesh are known to have more regular flocks (Sundar 2003) suggesting stable water conditions. The biggest known flocks are from the Etawah-Mainpuri region (see Table 6).

The pair bond in Sarus Cranes is thought to be permanent, though observations of "divorce" are available (Sundar in press). DNA studies to provide information on paternity and estimates of breakages of pair bond are absent for the Sarus Crane. Information from areas with differing densities of Sarus Cranes and with differing land use practices would be of conservation interest to see if these changes in habitat have an effect on the behaviour of pairs.

Territoriality

Studies in Keoladeo Park, Rajasthan (Gole 1991a,b, Ramachandran and Vijayan 1994) and in Nepal (Suwal 1999a) have provided information on territoriality by observing unmarked birds, and their estimates of territory size vary from 0.68-1 km^2 within Keoladeo Park to 1.5-27 km^2 in areas outside protected areas in Nepal and India (Suwal 1999a, Gole 1989). This needs to be verified and obtained for different areas using marked birds in areas with different land use practices. This has been started by the WII (Kaur and Choudhury 2002, Sundar 2002c) and data are presently being analyzed.

Mortality

Studies on mortality have proved that Sarus mortality around Keoladeo Park is due to application of pesticides (Muralidharan 1993), and reports of mortality episodes continue (Rana and Prakash in press). Other known reasons of adult Sarus mortality include collision/electrocution with power lines (Gole 1991, Sundar and Choudhury 2001). Feral dogs are suspected to kill adult Sarus Crane occasionally (Borad and Mukherjee 1999). Though there is anecdotal information on number of deaths, there is little information on effects of these mortality factors at the population

level. Future studies need to design fieldwork to obtain this information.

Crop damage

In Gujarat, estimates of damage to paddy crops by Sarus Cranes show that cranes can be responsible for losses of 0.2-13.6% of the produce in fields due to trampling and eating ripened grain, and up to 26% of grain can be eaten by cranes (Parasharya *et al.* 1986, Borad *et al.* 2001b). These studies, however, have not corrected for losses due to other sources including other granivorous birds, ungulates etc., and values provided are likely higher estimates. Sarus Cranes are also known to eat groundnut, potatoes, a variety of gram, and corn. Studies to assess damage to these crops and provide methods to reduce such damage are required.

Diet

There have been no detailed studies on the diet of the Sarus using standard methods such as stomach contents or fecal analyses. There is one small study that details characteristics of grit ingested by the Sarus based on gizzard contents of three birds killed due to pesticides (Sundar and Choudhury in press). Field observations suggest that the Sarus is omnivorous feeding on wetlands related foods like tubers, rhizomes, amphibians, reptiles, and insects (Hume and Marshall 1879, Walkinshaw 1973, Ghorpade 1975, Johnsgard 1983, BirdLife International 2001), and upland foods including paddy (Parasharya *et al.* 1986, Borad *et al.* 2001b), potatoes, peas, a variety of gram, and insects (Mukherjee 1999, K.S.G. Sundar, personal observation). Sarus Cranes occasionally take eggs of birds including water birds such as the Red-wattled Lapwing, Vanellus indicus (Mukherjee 1999), Spot-billed Duck, Anas poecilorhyncha (Sundar 2000) and Indian Skimmer, Rhynchops albicollis (Roland 2002), as also from nests of terrestrial species like the Spotted Doves, Streptopelia chinensis from nests on low branches (P. Gole, personal communication). Though Sarus Cranes take fish in captivity (Law 1930), it is unlikely that they eat fish in the wild. These observations suggest that the Sarus are opportunistic feeders. Studies on the feeding biology of the Sarus are lacking and are required.

Field techniques

There have been few studies to validate field techniques to count and study Sarus Cranes. Desai (1989) argued that it is possible to distinguish Sarus genders in the field by observations on parameters related to the red patch, but others have expressed difficulties to identify genders based on these characteristics (Gole 1987, Sundar *et al.* 2000). Sundar *et al.* (1999) provide a critique of techniques relating to morphometry, size and behaviour thought to assist in differentiating gender in Sarus Cranes in the field, and conclude that owing to uncertain results it is safer not to rely on these methods. Mukherjee *et al.* (1999), however, have calculated sex ratios of Sarus Cranes in Kheda, Gujarat, but do not indicate methods used to identify the genders. While sex ratio is an important parameter to assess the health of populations, there is no reliable information on this aspect on Sarus Cranes presently.

Mukherjee *et al.* (2001a,b) assessed techniques to count Sarus populations using road transects. These studies, however, have applied single methods and do not provide correction estimates within a method, or variation between different methods. Such studies to validate methods and provide estimates of variation and biases are essential.

Public opinion

Though characteristically believed to be protected by a largely vegetarian Hindu population (Archibald *et al.* 1981, Gole 1990, 1991a,b, 1996a,b, Baskaran 1999), public opinion appears to have changed, particularly in areas with high crane densities and intensive crop production due to crop damage (Vyas 1999b, Sundar *et al.* 2000). More alarming is the disappearance of the species from the mind of the rural community in areas that have experienced declines in Sarus Crane populations (e.g. in Madhya Pradesh and Haryana; Sundar *et al.* 2000). This would make wetland restoration activities using the Sarus as a flagship species less feasible in these areas since people no longer relate to the species.

Socio-economic concerns related to Sarus Crane conservation

Analyzing information on a broad scale Gole (1991a) concluded that Sarus Cranes are more abundant in areas that were categorized as "backward districts". Furthermore, more cranes were found in states with lower levels of urbanizations, smaller human densities, lower intensity of agriculture, smaller application of fertilizers and lesser use of machinery in farming techniques (Gole 1991a). The biggest lacuna in Sarus-related studies is the lack of a socio-economic approach to habitat conservation in recent years. Improving understanding of the various benefits of wetlands to village panchayats that hold responsibility to the protection of these habitats are required.

Another serious issue that needs to be better understood, and tackled, is application of pesticides, the large-scale application of which is responsible for crane mortality in some areas (Muralidharan 1993, Rana and Prakash in press). Studies to reduce crop damage, which is a serious issue (Parasharya et al. 1986, Borad 1998, Borad *et al*. 2001b), need to be encouraged and implemented.

Discussion

Surveys and other descriptive studies are undoubtedly important in setting a precedent for more advanced studies that base their design on the basic information available from preliminary studies. Understanding these birds, however, should not stagnate. Scientific rigour, repeatable and tested methods to suit field conditions in the country, and studies to understand aspects of ecology that would facilitate better applied conservation practices are required for the Sarus Crane.

Few studies on the Sarus Crane, to the best of our knowledge, have resulted in field conservation. None have resulted in changes in policy for conserving habitat of the cranes, though of late, popular science writings focusing attention on specific problems of wetland draining and deterioration have helped focus attention on wetland deterioration (Sundar 2001, Sethi 2001, Vardhan 2001, Kumar 2002). Most have served admirably to increase our knowledge and spread the message of the cranes' predicament in the highly populated Indian countryside. This needs to be moved to a higher level alongside improved field studies. There have been some discussions on affording the Sarus Crane better protection by moving it up in the Indian Wildlife Act from Schedule IV to Schedule I. We argue that this has little meaning for Sarus Crane conservation, as most cranes and pairs continue to live outside the realm of the Protected Area network. It is humanly impossible to monitor and protect every Sarus nest, most of which are on private lands, using a legal system of protection. Instead, we should move for policy changes to better protect wetlands and associated Sarus habitats, which are presently categorized as "wastelands" by the Indian Government, and work with farming communities to help reduce losses to crops by cranes due to trampling or building nests in paddy fields (see Gole 1991a,b, Mukherjee *et al*. 2001a, Sundar 2002a for discussions). To prevent increase in the illegal pet trade, which is prevalent in many areas in India presently (e.g. Mukerjee 2002), we concur with Meine and Archibald (1996) that it is necessary to upgrade the protection level for the Sarus Crane to Appendix I of the CITES agreement from its present listing in Appendix II.

Other proposals include reintroduction of Sarus Cranes to areas that historically included the species using captive propagation and release methods. Again, we argue that this would do little to enhance cranes populations in these areas since the original problems namely habitat deterioration, hunting and egg removal would still be in place. The money and effort would be better spent in educating private landowners who own most wetlands and by helping restore deteriorating wetlands. Cranes would, in all likelihood, spread naturally to restored areas, and this approach has obvious long-term merits. Bhandara Nature Club, Maharashtra is presently applying the latter method with positive effects on Sarus populations and local wetland quality (R. Job, personal communication). An initial effort at education and awarding farmers who protected Sarus nests has also been carried out successfully in Kota district of Rajasthan (Kaur and Choudhury 2003).

The history of Sarus Crane research in India is long and illustrious. With better application of standard techniques, better orientation of biologists and scientists to work on aspects that require immediate and specific attention, and positive criticism between various crane biologists in the country and outside, useful information to provide practical conservation priorities and methods can be obtained for the Sarus and its habitat. This will ensure that the Sarus Crane remains an integral part of the Indian landscape.

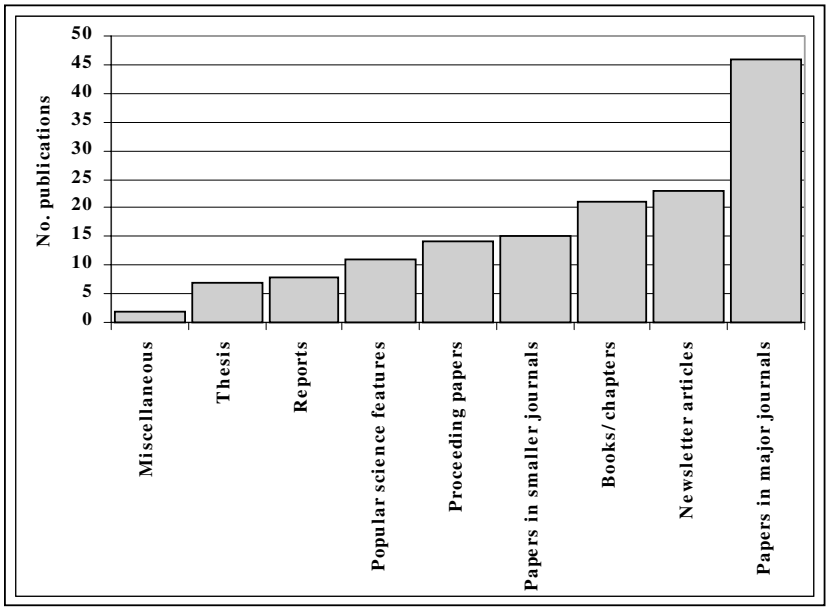


Figure 1 : Source of information on Indian Sarus Crane biology until September 2003. (N = 147; did not include newspaper clippings.)

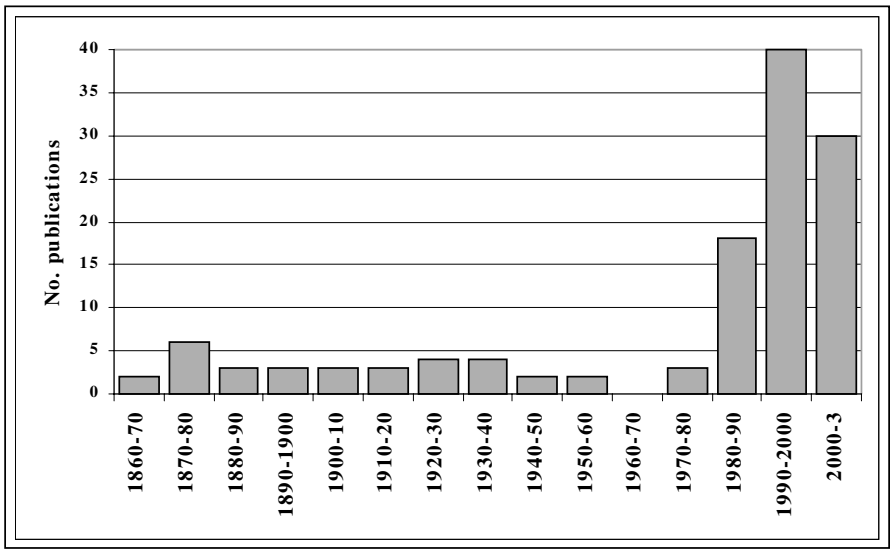


Figure 2 : Increase in publications on Indian Sarus Crane biology with time. (N = 123; did not include newspaper clippings and reports etc. that were subsequently published as papers.)

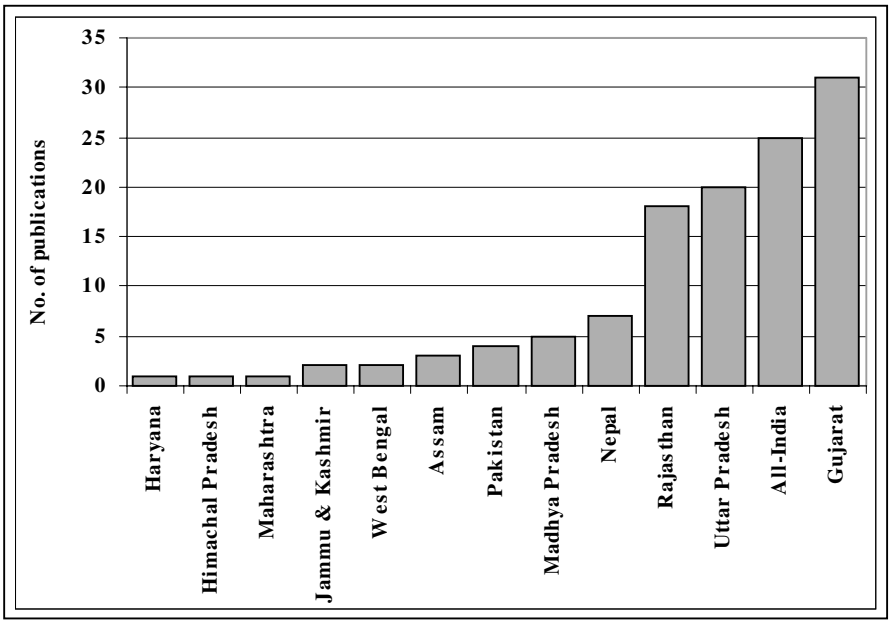


Figure 3 : Regional coverage of Indian Sarus Crane biology in the Indian subcontinent. (N =120; does not include newspaper clippings, reviews or regional checklists.)

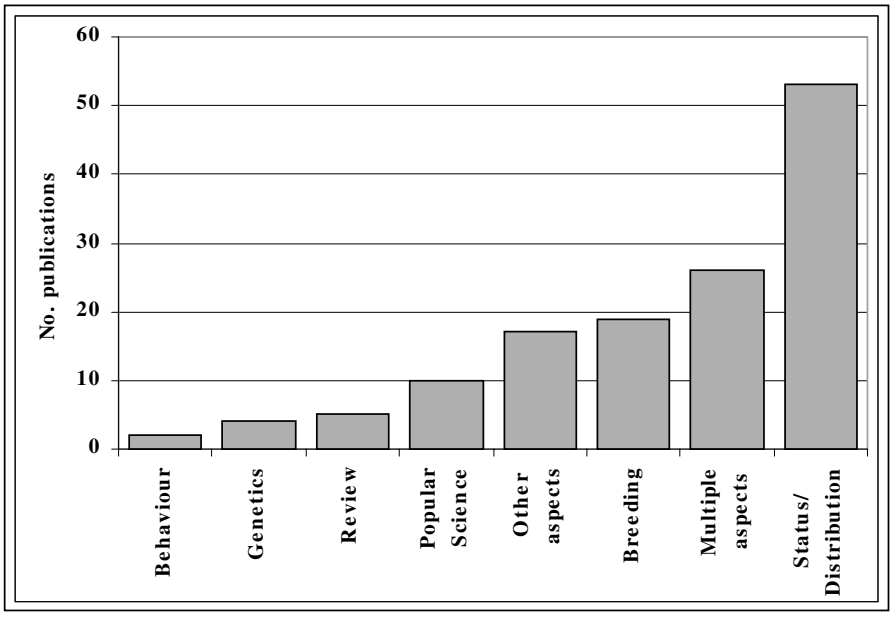


Figure 4 : Bias in aspects of ecology of Indian Sarus Cranes studied and published until October 2003. (N = 136; does not include checklists and newspaper clippings.)

Figure 5 : Relative abundance of the Indian Sarus Cranes as recorded in the coordinated Sarus Crane Counts of WII. Larger map was prepared by averaging values for places with information for more than one year.

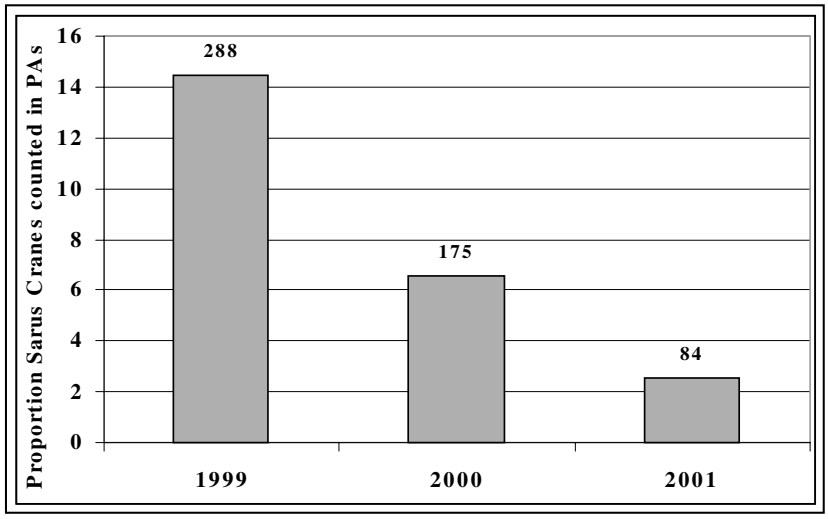


Figure 6 : Proportion of Indian Sarus Cranes counted in Protected Areas during the coordinated Sarus Crane Count of WII. Numbers on the bars indicate actual counts.

Table 1 : List of Protected Areas visited during the coordinated Sarus Crane Counts and Sarus Crane abundances recorded. (-: Not visited this particular year.)

State	Protected Area	Number of Sarus Cranes counted (adults, young)		
		1999	2000	2001
Assam	Bordoibam Bilmikh Bird Sanctuary	0	0	0
Gujarat	Thol Bird Sanctuary	10	-	-
	Velavadhar National Park	2,1	2	-
Haryana	Bhindawas Bird Sanctuary	-	-	2,1
	Sultanpur National Park	3	2	2
Himachal Pradesh	Dharanghati Wildlife Sanctuary	0	-	-
	Lippa Asrang Wildlife Sanctuary	0	-	-
	Rupi Bhaba Wildlife Sanctuary	0	-	-
	Shikari Devi Wildlife Sanctuary	0	-	-
Manipur	Loktak Park	0	-	-
Madhya Pradesh	Bandavgarh National Park	2	10	10
	Dehaila Lake, Karera Sanctuary	4,1	-	4,2
	Kanha National Park	0	-	-
	National Chambal Sanctuary	32,7	29,8	34,8
	Panpatha Reserve Forest	4	-	-
	Ralamandal Sanctuary	0	-	-
	Suryavanshi Tank in Narsinghgarg Wildlife Sanctuary	-	2,1	-
	Udanti Wildlife Sanctuary	-	0	-
	Van Vihar National Park	-	2,1	6,3
Punjab	Bir Moti Bagh Wildlife Sanctuary	-	0	-
Rajasthan	Keoladeo National Park	26,2	-	-
	Sariska Tiger Reserve	-	-	2,1
Uttar Pradesh	Dayalbagh Bird Sanctuary	3,2	-	-
	Dudwa National Park	2	-	-
	National Chambal Sanctuary	42,8	-	-
	Nawabganj Bird Sanctuary	4,1	4	5
	Parvati-Aranga Bird Sanctuary	80,31	-	-
	Patna Bird Sanctuary	19,2	-	-
	Saman Bird Sanctuary	-	4,2	0
	Sandi Bird Sanctuary	-	81,13	-
	Soor Sarovar Bird Sanctuary	-	14	-

Table 2 : Comparative account of selected demographic characteristics of Indian Sarus Cranes as calculated from all-India and regional surveys.*

Reference [Study period]	Area of study	% young	% pairs with two chicks	% successful breeding pairs
Parasharya *et al*. (1989) [1989]	Kheda district, Gujarat	21	—	42.87
Gole (1989) [1988-89]	All-India	13	28.69	21.71
	Gujarat	15	33.33	27.27
	Haryana	17	12.5	27.59
	Rajasthan	13	32.56	25.29
	Uttar Pradesh	11	27.12	18.5
Vyas (1999a) [1997-98]	Rajasthan and parts of Madhya Pradesh	19	48.3	27
Singh and Tatu (2000) [1998]	Kheda district, Gujarat	6.5	—	—
	Ahmedabad district, Gujarat	8	—	—
Mukherjee *et al*. (2002) [1996-98]	Kheda district, Gujarat			
	1996	8.95	5.88	32.69
	1997	10.53	41.18	35.42
	1998	11.04	28.57	48.28
Sundar *et al*. (2000b) [1998-99]	All-India	10	—	
	Gujarat	7	14.81	19.76
	Haryana	25	0	—
	Madhya Pradesh	18	0	—
	Maharashtra	50	0	—
	Rajasthan	10	16.67	—
	Uttar Pradesh	7	23.08	—
Sundar (2003) [2000-02]	Etawah and Mainpuri districts			
	2000	16	24.1	29.9
	2001	9	18.92	12.1
	2002	15	15.79	18.92
	Mean	14.59	19.01	28.12
	(SD)[1]	(9.31)	(12.51)	(10.06)

* Values were recalculated from the original source and may vary due to different methods used here. —: Not calculable from original reference or data unavailable;
1: Mean (SD) values only for state and district level.

Table 3 : Comparative account of habitat use by Indian Sarus Cranes.

Reference [Study period]	**Study area**	**Percent use**			
		Crop *fields*	*Natural wetlands*	*Other habitats*	*No. of* ***sightings***
Individuals					
Mukherjee 1999 [1997-98]	Kheda district, Gujarat				
	Monsoon: 1200-1600h	85.45	12.39	1.16	433
	Rest of the day	73.24	26.3	0.45	441
	Winter: 1200-1600h	53.05	46.42	0.53	377
	Rest of the day	72.49	24.54	2.97	269
	Summer: 1200-1600h	50.98	46.04	2.98	973
	Rest of the day	50.64	44.47	4.88	389
Suwal (1999a)		57.46	40.29	2.24	1159
Vyas (1999a) [1999]	Rajasthan and parts of Madhya Pradesh	27	73	0	332
Singh and Tatu (2000) [1998]	Kheda and Ahmedabad Districts, Gujarat	77.86	19.55	2.6	1084
Sundar et al. *(2000b)* [1998-99]	All-India	50.31	47.13	2.6	1761
Latt (2002) [2000-1]	Keoladeo National Park, Rajasthan				
	Winter	5	20	59	-
	Summer		37	75	-
Vyas (2002) [1993-4]	Kota, Rajasthan	55	22	23	423
Sundar (2003) [2000-02]	Etawah and Mainpuri Districts, Uttar Pradesh				
	2000	37.24	60.03	2.73	733
	2001	51.4	36.4	12.2	1120
	2002	49.18	46.91	3.91	549
Groups					
Gole (1989) [1988-89]	All-India	42.55	52.15	5.3	604
	Gujarat	9.36	81.25	9.38	42
	Haryana	57.31	31.83	2.87	32
	Rajasthan	19.34	70.17	10.5	181
	Uttar Pradesh	45.24	54.76	0	349
Mukherjee 1999 (1997-8]	Kheda district, Gujarat				
	Monsoon: 1200-1600h	84.57	14.82	0.61	162
	Rest of the day	72.11	27.21	0.68	147
	Winter: 1200-1600h	60	38.46	1.54	65
	Rest of the day	71.62	22.97	5.41	74

	Summer: 1200-1600h	69.15	25.53	5.32	94
	Rest of the day	65.96	29.79	4.26	47
Sundar 2003 [2000-02]	Etawah and Mainpuri districts				
	2000	71.72	20	8.28	145
	2001	69	11.6	19.4	310
	2002	72.58	20.16	7.26	124

Table 4 : Breeding period and incubation time of the Indian Sarus Crane.
(BMNH: British Museum of Natural History, CNMH: Chicago Natural History Museum, ICF: International Crane Foundation, 1: From Walkinshaw 1973)

Reference	**Incubation period (days)**	**Month of nest initiation (laying of first egg)**											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Records from the wild													
Berger, A.J. *in litt*. 1964[1]									+	+			
Jerdon 1864					+								
BMNH & CNMH records 1865-1967[1]			+	+		+		+	+	+		+	+
Barnes 1886			+	+					+	+			
Blaauw 1897							+	+					
O'Brien 1909		+											
Mosse 1910			+										
King 1911				+					+				
Whitehead 1911													+
D'Abreau 1912, 1935								+	+	+			
Bates 1925			+									+	
Hill 1930											+		
Bates 1935[1]									+				
Jehangir (1603-27) (in Ali 1927)	34												
Ali 1940										+			
Walkinshaw 1973										+			
Breeden and Breeden 1982	33,34			+					+				
Kulshreshtha and Vyas 1989			+	+	+			+	+	+	+		
Singh and Khan 1989								+	+	+	+		
Iqubal 1992	32								+				
Ramachandran and Vijayan 1994	33		+	+					+	+	+		
Mukherjee 1999							+	+	+	+	+		
Vyas 1999b				+	+					+	+		
Records from captivity													
Walkinshaw 1947	32, 36						+	+	+	+			
Lahiri 1955	28												
Ellis *et al*. 1996 and ICF, unpublished data	33,35					+	+	+	+				

Table 5 : Information on aspects of breeding biology of the Indian Sarus Crane.

Reference	Study area	Average **clutch size**	**Success**
Ramachandran and Vijayan 1994	Keoladeo, Rajasthan		
	1984		20% fledging success
	1985		37.5% fledging success
Suwal 1999a	Rupandehi, Nepal	1.05	—
Vyas 1999b	Kota, Rajasthan	1.7	1.35 chicks per pair
Mukherjee *et al*. 2001b	Kheda, Gujarat	2.0	25.74% fledging success

Table 6 : Flock sizes recorded for the Indian Sarus Cranes. For sites with information on multiple years in a single study, the maximum value is provided. Only sites with at least 50 birds are listed here.

Reference	State	Month/Year	Area, District	No. Sarus
Acharya 1936				
Breeden and Breeden 1982	Rajasthan	December/ 1979	Keoladeo National Park, Bharatpur	434
Saxena 1990	Madhya Pradesh	January/ 1987	Madhav National Park	50
Prasad *et al*. 1993	Uttar Pradesh	May/ 1993	Hardoi Lake, Etawah	213
Ramachandra and Vijayan 1994	Rajasthan	April/ 1985	Keoladeo National Park, Bharatpur	>250
Mukherjee *et al*. 1999	Gujarat	May/ 1998	Daloli Reservoir	98
		June/ 1998	Gobrapura Reservoir	109
		May/ 1998	Machiyel Tank	92
		June/ 1998	Narda Reservoir	93
Sundar 1999b	Uttar Pradesh	June/ 1999	Patna Bird Sanctuary, Etah	120
			Sarsai Nawar Lake, Etawah	166
Sundar *et al*. 2000b	Madhya Pradesh	July/ 1998	Yashwanth Sagar Reservoir	64
Sundar 2003	Uttar Pradesh	June/ 2000-2	Ambarpur Marsh, Mainpuri	97
			Bidhuna Lake, Mainpuri	81
			Gaad lake, Mainpuri	111
			Sarsai Nawar Lake, Etawah	179
Sundar, K.S.G. unpublished information	Uttar Pradesh	Jan/ 2000	Ambarpur Marsh, Mainpuri	412
		Feb/ 2001	Gaad Lake, Mainpuri	260
		Feb/ 2001	Sarsai Nawar Lake, Etawah	385
		May/ 2001	Sarsai Nawar Lake, Etawah	245

Acknowledgements

We thank Mr. Prakash Gole for inviting this paper for the special issue of the *J. Ecol. Soc.* on Sarus Cranes. This paper was written as part of the Sarus Crane project of the Wildlife Institute of India (WII) and we thank the Director, Mr. S.K. Mukherjee for facilities and infrastructure. KSGS thanks the following people for various help: fellowships from the International Crane Foundation (ICF) and the U.S. Fish and Wildlife Service made travel to and stay at ICF possible during the writing of the paper, and I thank G.W. Archibald, L. Dando, D. Ferguson, P. Ghosh, and J. Harris for facilitating the same at various levels; D. Avinandan, B. Didrickson and A. Pittie for help with bibliographies. Unpublished information, discussions on various aspects of Sarus Crane biology, and paper clippings towards this review were kindly provided by G.W. Archibald (ICF), J. Barzen (ICF), J.W. den Besten (Himachal Pradesh), J. Kaur (WII), A. Khan (Pakistan), K. Maguire (ICF), C. Mirande (ICF), R. Suwal (Nepal), and I thank them for sharing the information. A previous draft of the manuscript benefited from the critical scrutiny of G.W. Archibald, B. Didrickson, D. Ferguson, P. Gole, M. Hayes, M.B. Krishna, A. Lacy, and J. Zajicek, and we thank them for their help.

References

Acharya, H.N.G 1936. Sarus flocks. *J. Bombay Natl. Hist. Soc.* 38: 831.

Adam, R.M. 1872-3. Notes on the birds of the Sambhur lake and its vicinity. *Stray Feathers* I: 361-404.

Ahmad, F.H. 1995a. Sarus Crane sighting in Pakistan. Unpublished manuscript, ICF Library, Wisconsin, U.S.A. 1pp.

Ahmad, F.H. 1995b. Sarus Cranes at Bhansar Lake (Nagarparkar). Unpublished manuscript, ICF Library, Wisconsin, U.S.A. 1pp.

Ali, S. 1927. The moghul emperors of India as naturalists & sportsman. Part II. *J. Bombay Natl. Hist. Soc.* 32: 33-63.

Ali, S. 1940. The birds of central India. Part II. *J. Bombay Natl. Hist. Soc.* 41: 470-488.

Ali, S. 1958. Notes on the Sarus Crane. Early 'imprinting' of vital commands. *J. Bombay Natl. Hist. Soc.* 55: 166-168.

Ali, S and Ripley, S.D. 1980. Handbook of the Birds of Indian and Pakistan. Vol 2. Megapodes to Crab Plover. Oxford University Press, Delhi.

Ali, S.K. 1993. Reappearance of the Sarus Cranes in Pakistan. *Wildlife & Environment* Vol. 2 of 3. (Oct.–Dec. 1993): 8.

Allan, D.G. 1996. A review of the biology and conservation status of cranes. In: Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N. (eds.). Proceedings African Crane & Wetlands Workshop. Pp. 13-51.

Anon. 1989. Indian Working Group on Cranes. In: Proceedings, Asian Crane Congress, Rajkot, Gujarat. Pp. 11.

Archibald, G.W. 1976. Crane taxonomy as revealed by the unison calls. In: Proceedings of the International Crane Workshop, Oklahoma State Publishing and Printing Department, U.S.A. Pp. 225-251.

Archibald, G.W. and Meine, C.D. 1996. Family Gruidae (Cranes). In: del Hoyo J, Elliott A, Sargatal J (eds.) Handbook of the birds of the world. Vol. 3. Hoatzin to Auks. Lynx Edicions, Barcelona. Pp. 67-75.

Archibald, G.W. and Pasquier, R.F. (eds.) 1987. Proceedings of the 1983 International Crane Workshop, Bharatpur, India. International Crane Foundation, Baraboo, Wisconsin, U.S.A.

Archibald, G.W., Shigeta, Y., Matsumoto, K. and Momose, K. 1981. Endangered cranes. In: Lewis JC, Masatomi H (eds.) Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on Cranes, International Council for Bird Preservation, U.S.A. Pp. 1-12.

Baker, E.C.S. 1899. The birds of north Cachar. *J. Bombay Natl. Hist. Soc.* 12: 486-510.

Baker, E.C.S. 1928a. The fauna of British India including Ceylon and Burma. 2nd Edition. Taylor and Francis, London.

Baker, E.C.S. 1928b. The game birds of the Indian Empire. Vol V. The waders and other semi-sporting birds. Part VII. *J. Bombay Natl. Hist. Soc.* 33: 1-6.

Ball, V. 1874. On the avifauna of the Chutia (Chota) Nagpur division, SW Frontier of Bengal. *Stray Feathers* II: 355-440.

Banerjee, A.K. and Gopakumar, G. 1986. Effects of drought on wintering cranes at Rajkot, Saurashtra. *Cheetal* 27: 31-36.

Barnes, H.E. 1886. Birds nesting in Rajpootana. *J. Bombay Natl. Hist. Soc.* 1:38-62.

Barnes, H.E. 1887. Note on the irregular breeding of *Grus antigone*, the Sarus. *J. Bombay Natl. Hist. Soc.* 2: 149-150.

Baskaran, S.T. 1999. The dance of the Sarus. In: Baskaran ST (ed.) The Dance of the Sarus: Essays of a wandering naturalist. Oxford University Press, New Delhi. Pp. 1-5.

Bates, R.S.P. 1925. Birds-nesting with a camera in India. *J. Bombay Natl. Hist. Soc.* 30:306-313.

Beavan, R.C. 1868. Notes on various Indian birds. *Ibis* 2: 370-406.

Beilfuss, R. and Suwal, R.N. 1999. Restoring a sacred home for the Sarus Crane. *The ICF-Bugle* 26: 1-3.

Bhattarcharjee, P.C. and Saikia, P. 1990. A report on the cranes of Assam. *J. Ecol. Soc.* 3: 27-28.

BirdLife International. 2001. Sarus Crane *Grus antigone*. In: Threatened Birds of Asia: the BirdLife International Red Data Book. BirdLife International, Cambridge, UK. Pp. 1118-1150.

Blaauw, F.E. 1897. A monograph of the cranes. Leiden and London. 22 plates + 64 pp.

Blyth, E. 1881. The natural history of the cranes: greatly enlarged, and reprinted, with numerous illustrations by WB Tegetmeier F.Z.S. Horace Cox & R.H. Porter, London.

Borad, C.K. 1998. Appraisal of damage potential and breeding ecology of the Indian Sarus Crane *Grus antigone* Linnaeus in paddy crop ecosystem. M.Sc. Dissertation, Gujarat Agricultural University, SK Nagar, Gujarat.

Borad, C.K. and Mukherjee, A. 2000. Cranes and dogs. *Newsletter for Birdwatchers* 40(2): 26.

Borad, C.K., Mukherjee, A. and Parasharya, B.M. 2001a. Nest site selection by the Indian Sarus Crane in the paddy crop ecosystem. *Biol. Cons.* 98: 89-96.

Borad, C.K., Mukherjee, A. and Parasharya, B.M. 2001b. Damage potential of Indian sarus crane in paddy crop agroecosystem in Kheda district, Gujarat, India. *Agriculture, Ecosystems and Envt.* 86: 211-215.

Breeden, S. and Breeden, B. 1982. The drought of 1979-1980 at the Keoladeo Ghana Sanctuary, Bharatpur, Rajasthan. *J. Bombay Natl. Hist. Soc.* 79: 1-37.

Bulkley, H. 1893. The breeding season of the Sarus Crane. *J. Bombay Natl. Hist. Soc.* 8: 148.

Butler, E.A. 1876. Notes on the avifauna of Mount Aboo and northern Guzerat. *Stray Feathers* IV (Nos. 1,2&3): 1-41.

Chaturvedi, N. 1992. Folklore: The Sarus Crane. *Hornbill* 1992(4): 23.

Choudhury, A. 1990. Status of Barheaded Goose and Cranes in Assam. *J. Ecol. Soc.* 3: 31-36.

Choudhury, A. 1998. Mammals, birds and reptiles of Dibru-Saikhowa Sanctuary, Assam, India. *Oryx* 32: 192-200.

Choudhury, A. 2002. Status and conservation of cranes in Northeast India. In: Rahmani, A.R. and Ugra, G. (eds.) Birds of Wetlands and Grasslands: Proceedings of the Sálim Ali Centenary Seminar on conservation of avifauna of wetlands and grasslands. Pp. 41-44.

Choudhury, B.C., Kaur, J. and Sundar, K.S.G. 1999. Sarus Crane Count - 1999. Wildlife Institute of India, Dehradun, India.

Conway, W.G. 1965. Egg replacement by a pair of Sarus Cranes *Grus antigone antigone* L, at New York Zoological Park. *The Intl. Zoo Yearbook* v: 129.

D'Abreau, E.A. 1912. Notes on the bird collection trip in the Balaghat District of the Central Provinces. *J. Bombay Natl. Hist. Soc.* 21: 1158-1169.

D'Abreau, E.A. 1935. A list of birds of the Central Provinces. *J. Bombay Natl. Hist. Soc.* 38: 95-116

Desai, R.M. 1980. Studies in the biology of the Indian Sarus Crane. Unpublished M. Phil. Thesis, Gujarat University, Surat.

Desai, R.M. 1989. Observations on sexual dimorphism in the Indian Sarus Crane (*Grus antigone antigone*). Paper presented at the Asian Crane Congress, Rajkot, Gujarat.

Didrickson, B. in preparation. The little book of crane tales. International Crane Foundation, Wisconsin, Baraboo, U.S.A.

Dubois, A. 1904. Synopsis Avium. Noveau Manuel d'Ornithologie. H. Lamertin, Brussels.

Ellis, D.H., Gee, G.F. and Mirande, C.M. (ed.) 1996. Cranes: Their biology, husbandry, and conservation. National Biological Service/ International Crane Foundation, U.S.A. Pp. 67.

Ghorpade, A.M. 1975. A note on the feeding of the Sarus Crane *Grus antigone* (Linnaeus). *J. Bombay Natl. Hist. Soc.* 72: 199-200.

Gole, P. 1985. Cranes wintering in Saurashtra. *J. Bombay Natl. Hist. Soc.* 81: 699-700.

Gole, P. 1987. Observing the Sarus. In: Archibald, G.W. and Pasquier, R.F. (eds.). Proceedings 1983 International Crane Workshop, ICF, Wisconsin, USA. Pp. 107-114.

Gole, P. 1989. The status and ecological requirements of Sarus Crane. Phase I. Report submitted to the Ministry of Environment and Forests, Government of India.

Gole P 1990. The status and ecological requirement of Sarus Cranes. Phase II. Unpublished report to the Ministry of Environment and Forests, Govt. of India.

Gole, P. 1991a. Welfare of the tallest flying bird in the world. *J. Ecol. Soc.* 4: 29-42.

Gole, P. 1991b. The life and times of the tallest flying bird in the world. *Sanctuary Asia* 11(3): 26-35.

Gole, P. 1996a. A guide to the cranes of India. Bombay

Natural History Society, Bombay, India.
Gole, P. 1996b. Environment and ornithology in India. Rawat Publications, Jaipur & New Delhi. 262 pp.
Hasan, M. 1996. Of cranes and men. *Hornbill* 1996(4): 8-9.
Hill, A.J.R. 1930. Nesting of the Sarus (*Grus antigone*). *J. Bombay Natl. Hist. Soc.* 34: 582.
Hingston, R.W.G. 1920. A list of birds of Dharamsala. *J. Bombay Natl. Hist. Soc.* 27: 555-572.
Hopwood, C. 1912. A list of birds from Arakan. *J. Bombay Natl. Hist. Soc.* 21: 1196-1121.
Hume, A.O. 1872-3. Contributions to the ornithology of India - Sindh. No. II. *Stray Feathers* I: 44-50, 91-289.
Humes, A.O. and Davidson, W. 1878. A revised list of the birds of Tenasserim. *Stray Feathers* VI: 1-524.
Hume, A.O. and Marshal, C.H.T. 1879. The game birds of India, Burmah, and Ceylon. Vol III. John Bale, London.
Inglis, C.M. 1902. The birds of the Madhubani subdivision of the Darbhanga District, Tirhut, with notes on species noticed elsewhere in the district. Part V. *J. Bombay Natl. Hist. Soc.* 14: 764-771.
Iqubal, P. 1992. Breeding behaviour in Sarus Crane (*Grus antigone antigone*). Unpublished M.Sc. Thesis, Aligarh Muslim University, Aligarh, Uttar Pradesh.
Jerdon, J.C. 1864. The birds of India. George Wyman & Co., Calcutta. 870 pp.
Johnsgard, P.A. 1983. Cranes of the world. Croom Helm, London & Canberra. 257 pp.
Jones, K.L. 2003. Genetic variation and structure in Cranes: A comparison among species. Unpublished PhD. Thesis, University of Illinois, Chicago. 142 pp.
Kaur, J. and Choudhury, B.C. 2002. The arid-zone Sarus Crane. *Wildlife Institute of India Newsletter* 8(4)&9(1): 13-14.
Kaur, J. and Choudhury, B.C. 2003. Recognition of community involvement in Sarus Crane conservation in Kota, Rajasthan. *Mistnet* 3(4; October-December): 6.
Kaur, J., Sundar, K.S.G. and Choudhury, B.C. 2002. Sarus Crane Count - 2001. Wildlife Institute of India, Dehradun, India.
Khurshid, N. and Munaf, A. 1994. Return of the Sarus to Pakistan. *Natura* (Autumn – winter 1994): 9-11.
King, R.C.H.M. 1911. The resident birds of the Saugor and Damoh districts, Central Provinces. *J. Bombay Natl. Hist. Soc.* 21: 87-103.
Krajewski, C. 1989. Phylogenetic relationships among cranes (Gruiformes: Gruidae) based on DNA hybridization. *Auk* 106: 603-618.
Krajewski, C. 1990. Relative rates of single-copy DNA evolution in Cranes. *Mol. Biol. Evol.* 7: 65-73.
Krajewski, C. and Fetzner, J.W. Jr. 1994. Phylogeny of cranes (Gruiformes: Gruidae) based on cytochrome-b DNA sequences. *Auk* 111: 351-365.
Krajewski, C. and Wood, T.C. 1995. Mitochondrial DNA relationships between the Sarus Crane species group (Gruiformes: Gruidae). *Emu* 95: 99-105.
Kulshreshtha, M. and Vyas, R. 1989. Status of sarus crane (*Grus antigone*) along canals and lakes of Kota. Paper presented at the Asian Crane Congress, Rajkot, Gujarat.
Lahiri, R.K. 1955. Breeding of Sarus Crane [*Antigone a. antigone* (Linn.)] in captivity. *J. Bombay Natl. Hist. Soc.* 53: 130-131.
Latt, T.N. 2002. Seasonal change in social structure, behaviour and habitat use by Sarus Crane in the semi-arid region of north-western India. Unpublished M.Sc. Thesis, Saurashtra University, Rajkot, Gujarat.
Law, S.C. 1930. Fish-eating habit of the Sarus Crane (*Grus antigone*). *J. Bombay Natl. Hist. Soc.* 34: 582-3.
Leslie, J. 1998. A bird bereaved: The identity and significance of Valmiki's *krãunca*. *J. Indian Philosophy* 26: 455-487.
Livesey, T.R. 1937. Sarus flocks. *J. Bombay Natl. Hist. Soc.* 39: 420-421.
Lowther, E.H.N. 1944. Notes on some Indian birds VIII. By tank and jhil. *J. Bombay Natl. Hist. Soc.* 44: 355-373.
Meine, C.D. and Archibald, G.W. 1996. The cranes:- Status survey and conservation action plan. IUCN, Gland, Switzerland and Cambridge, UK. 294 pp.
Menon, G.K., Shah, R.V. and Jani, M.B. 1980. Observation on integumentary modifications and feathering on the head and neck of the Sarus Crane, *Grus antigone antigone*. *Pavo* 18(1&2): 10-16.
Mosse, A.H. 1910. Nidification of the Sarus Crane. *J. Bombay Natl. Hist. Soc.* 20: 218.
Mukerjee, S. 2002. Poaching. The no fly zone. *Outlook* xlii(41; 21 October): 66-68.
Mukherjee, A. 1999. Ecological study on the Indian Sarus Crane *Grus antigone* in the central Gujarat. Ph.D. Dissertation, Saurashtra University, Rajkot, Gujarat. 281 pp.
Mukherjee, A. 2002. Observations on the mating behaviour of the Indian Sarus Crane *Grus antigone antigone* in the wild. *J. Bombay Natl. Hist. Soc.* 99: 108-113.

Mukherjee, A., Borad, C.K. and Parasharya, B.M. 2000. The Indian Sarus Crane (*Grus antigone antigone*) - a threatened wetland species. *Newsletter for Birdwatchers* 40(6): 77-78.

Mukherjee, A., Borad, C.K. and Parasharya, B.M. 2002. Breeding performance of the Indian sarus crane in the agricultural landscape of western India. *Biol. Cons*. 105: 263-269.

Mukherjee, A., Borad, C.K., Parasharya, B.M. and Soni, V.C. 2001a. Factors affecting distribution of the Sarus crane *Grus antigone antigone* in Kheda District, Gujarat. *J. Bombay Natl. Hist. Soc.* 98: 379-384.

Mukherjee, A., Borad, C.K., Patel, S. and Parasharya, B.M. 2001b. Selection of suitable census method for the Indian sarus crane *Grus antigone antigone*. *J. Bombay Natl. Hist. Soc.* 98: 237-241.

Mukherjee, A., Soni, V.C., Borad, C.K. and Parasharya, B.M. 1999. Diurnal use of reservoirs by the Indian Sarus Crane (*Grus antigone*) during summer months. *Zoos' Print Journal* 14(7): 72-74.

Muralidharan, S. 1992. Poisoning the Sarus. *Hornbill* 1992(1): 2-7.

Muralidharan, S .1993. Aldrin poisoning of Sarus cranes (*Grus antigone*) and a few granivorous birds in Keoladeo National Park, Bharatpur, India. *Ecotoxicology* 2: 196-202.

Murray, J.A. 1890. The birds of British India and its dependencies. Reprinted by the International Book Distributors, Dehradun, 1985, India. 830 pp.

Nesbitt, S.A, Schwikert, S.T. and Folk, M.J. 2002. Natal dispersal in Florida Sandhill Cranes. *J. Wildl. Manage.* 66: 349-352.

Nowald, G., Mewes, W., Alonso, J.C. and Alonso, J.A. 1996. Farbmarkierung von Kranichen *Grus grus* in Deutschland – ein Zwischenericht. *Vogelwelt* 117:119-124.

Oates, E.W. 1877. Notes on the nidification of some Burmese birds. *Stray Feathers* V: 141-170.

O'Brien, E. 1909. Nidification of the Sarus Crane (*Grus antigone*). *J. Bombay Natl. Hist. Soc.* 19: 524.

Parasharya, B.M. 1998. Importance of paddy crop ecosystem for bird conservation. Paper presented at the National Seminar on Wildlife Conservation, Research and Management, Aug. 10-13, 1998, WII, Dehradun, India.

Parasharya, B.M., Dodia, J.F., Yadav, D.N. and Patel, R.C. 1986. Sarus crane damage to paddy crop. *Pavo* 24(1&2): 87-90.

Parasharya, B.M., Mathew, K.L., Yadav, D.N. 1989. Status and habitat preference of Indian Sarus Crane in Gujarat. Paper presented in the Asian Crane Congress, Rajkot, Gujarat.

Parasharya, B.M., Patel, A.D., Patel, S.B. and Chauhan, R.B. 1996. Sarus Crane population decline: a result of conflict with human interests. Paper presented in the Salim Ali Centenary Seminar on conservation of Wetlands and Grasslands, Bombay, India.

Pershouse, S. 1911. Nidification of the Sarus Crane (*Grus antigone*). *J. Bombay Natl. Hist. Soc.* 20: 854.

Peters, J.L. 1934. Check-list of birds of the world. Vol. 2. Cambridge University Press, Cambridge.

Prasad, S.N., Ramachandran, N.K., Das, H.S. and Singh DF 1993. Sarus congregations in Uttar Pradesh. *Newsletter for Birdwatchers* 33(4): 68.

Pittie, A. 2001. A Bibliographic Index to the Ornithology of the Indian Subcontinent. CD-ROM, DOS. Published by the author. Hyderabad, India.

Rai, R. and Badhwar, I. 1989. Of human bondage. *India Today* (April 15, 1989): 83-93.

Ramachandran, N.K. and Vijayan, V.S. 1994. Distribution and general ecology of the Sarus Crane (*Grus antigone*) in Keoladeo National Park, Bharatpur, Rajasthan. *J. Bombay Natl. Hist. Soc.* 91: 211-223.

Rana, G., and Prakash, V. in press. Unusually high mortality of cranes in adjoining areas of Keoladeo National Park, Bharatpur, Rajasthan. *J. Bombay Natl. Hist. Soc.*

Reid, G. 1881. The birds of the Lucknow Civil Division. Part II. *Stray Feathers* X: 1-88.

Roberts, T.J. 1977. Crane catchers of the Kurram valley. *Wildlife* 19(9): 398-401.

Roland, B. 2002. India 30th March - 11th April 2002. URL: <www.surfbirds.com/mb/trips/india-0402-rb.html>. Accessed Nov 22, 2003.

Saxena, R. 1990. The cranes of Madhav National Park. *J. Ecol. Soc*. 3: 37-40.

Sethi, N. 2001. Last call. *Down to Earth* 10(5): 25-29.

Sharpe, R.B. 1894. Catalogue of birds in the British Museum, Vol. XXIII. British Museum (Natural History), London.

Sharpe, R.B. 1899. A hand-list of the genera and species of birds, Vol. I. British Museum (Natural History), London.

Shiva Kumar, N. 2002. World Bank plan: cranes create flutter. *Pitta* 130: 1, 4.

Shreshtha, B.S.P 1996. Population status of Sarus Crane in Nepal. Unpublished M.Sc. Thesis, New Mexico State University, Las Cruces, New Mexico.

Shrestha, M. 1995. Human attitudes and cranes in Nepal's Terai Region. In The proceedings of the third annual international crane symposium: People, water and wildlife: Human population im-

pacts on cranes, Boulder, Colorado: National Audubon Society, 53-5.

Singh, A.P. 2003. Sighting of Sarus Crane in Himachal Pradesh. *Newsletter for Birdwatchers* 43(1) Jan/Feb: 12.

Singh, B. 1993. A checklist of birds of Punjab. Punjab Government Press.

Singh, H.S. and Tatu, K. 2000. A study on Indian Sarus Crane (*Grus antigone antigone*) in Gujarat state (with emphasis on its status in Kheda and Ahmedabad districts). Gujarat Ecological Education & Research (GEER) Foundation, Gandhinagar, Gujarat.

Singh, V.P. and Khan, S.A. 1989. Status of Sarus (*Grus antigone*) in Lakhimpur-Kheri district. Paper presented at the Asian Crane Congress, Rajkot, Gujarat.

Subramanya, S. 1994. Paintings of Indian birds by Lady Elizabeth Gwillim at McGill University, Canada. *Newsletter for Birdwatchers* 34(4) Jul/ Aug: 74-76.

Sundar, K.S.G. 1999a. The Sarus in Jammu, the Fulvous Whistling-duck in north Bengal and birds in Pondicherry University Campus - a reply. *Newsletter for Birdwatchers* 39(3): 41-43.

Sundar, K.S.G. 1999b. Black-necked Storks, Sarus Cranes and Drongo Cuckoos. *Newsletter for Birdwatchers* 39(5): 71-72.

Sundar, K.S.G. 2000. Eggs in the diet of the Sarus Crane *Grus antigone* (Linn.). *J. Bombay Natl. Hist. Soc.* 97: 428-429.

Sundar, K.S.G. 2001. Where the Sarus duet. *Sanctuary Asia* xxi (Oct 2001): 62-67

Sundar, K.S.G. 2002a. Conserving the Sarus Crane in India: a life-history perspective. *Science Today* 5: 34-37.

Sundar, K.S.G. 2002b. Seeing life Sarus style. *ICF-Bugle* (4): 4-5.

Sundar, K.S.G. 2002c. Working with the Sarus Crane. *Wildlife Institute of India Newsletter* 9 (Winter 2002): 1-3.

Sundar, K.S.G. 2003. Using road transects to monitor abundance, demography and habitat use of Sarus Crane *Grus antigone*: A case study from Etawah and Mainpuri districts, Uttar Pradesh. Unpublished report submitted to the International Crane Foundation, U.S.A. 18pp.

Sundar, K.S.G. in press. Observations of mate change and other aspects of pair-bond in the Sarus Crane *Grus antigone*. *J. Bombay Natl. Hist. Soc.*

Sundar, K.S.G. and Choudhury, B.C. 2001. A note on Sarus Crane *Grus antigone* mortality due to collision with high-tension power lines. *J. Bombay Natl. Hist. Soc.* 98: 108-110.

Sundar, K.S.G. and Choudhury, B.C. 2003. Nest sanitation in Sarus Cranes *Grus antigone* in Uttar Pradesh, India. *Forktail* 19: 144-146.

Sundar, K.S.G. and Choudhury, C. in press. Grit use in the Sarus Crane *Grus antigone*. *J. Bombay Natl. Hist. Soc.*

Sundar, K.S.G., Kaur, J. and Choudhury, B.C. 1999. Distribution, general ecology and conservation status of the Indian Sarus Crane (*Grus antigone antigone*) in India: results of an all-India survey 1998-99. WII, Dehradun, India. 122 pp.

Sundar, K.S.G., Choudhury, B.C. and Kaur, J. 2000a. Sarus Crane Count - 2000. Wildlife Institute of India, Dehradun, India.

Sundar, K.S.G., Kaur, J. and Choudhury, B.C. 2000b. Distribution, demography and conservation status of the Indian Sarus Crane (*Grus antigone antigone*) in India. *J. Bombay Natl. Hist. Soc.* 97: 319-339.

Suwal, R.N. 1995. Crane ecology and bird conservation in Lumbini (1992-93). In The proceedings of the third annual international crane symposium: People, water and wildlife: Human population impacts on cranes. National Audubon Society, Boulder, Colorado, U.S.A. Pp. 35-52.

Suwal, R.N. 1999a. Studies on the habitat preference, movements, nesting and population dynamics of Sarus Cranes in Lumbini. M.Sc. Thesis, Tribhuvan University, Kirthipur, Nepal.

Suwal, R.N. 1999b. Tribute to cranes in the holyland. *Puskarni: Lumbini Crane Sanctuary Newsletter* 2: 1-2.

Suwal, R.N and Shreshtha, M.K. 1992. Large waders and wetland of terai. Unpublished report submitted to the U.S. Fish & Wildlife Service and King Mahendra Trust for Nature Conservation, Nepal.

Symons, H.S. 1909. Sarus Crane (*Grus antigone*) in Salsette. *J. Bombay Natl. Hist. Soc.* 19: 261.

Tatu, K. 2000. Population status of Indian Sarus Crane (*Grus antigone antigone*) in Gujarat state. *Indian Forester* October: 1085-1093.

Thapa, V.J. and Parihar, R. 1998. Savage harvest. *India Today* (Nov. 2): 60-66.

Thompson, P.M., Harvey, W.G., Johnson, D.L., Millin, D.J., Rashid, S.M.A., Scott, D.A., Stanford, C. and Woolner, J.D. 1993. Recent notable records from Bangladesh. *Forktail* 9: 12-44.

Vardhan, H. (ed.) 2001. Indian Sarus in peril. 5th Indian Birding Fair 2001, Nov 1-2, Tourism & Wildlife Society of India, Jaipur, Rajasthan, India.

Vyas, R. 1999a. Status survey of Sarus Cranes in Rajasthan. Unpublished report, Hadoti Naturalists Society, Kota, Rajasthan, India.

Vyas, R. 1999b. Breeding success and chick mortality in Sarus Cranes. *Newsletter for Birdwatchers* 39(1): 5-7.

Vyas, R. 2002. Habitat utilization by Sarus Crane *Grus antigone* and the importance of man-made wetlands in its conservation. In: Rahmani, A.R. and Ugra, G. (eds.) Birds of Wetlands and Grasslands: Proceedings of the Sálim Ali Centenary Seminar on conservation of avifauna of wetlands and grasslands, Mumbai, India. Pp. 35-40.

Walkinshaw, L.H. 1947. Some nesting records of the Sarus Crane in North American zoos. *Auk* 64: 602-615.

Walkinshaw, L.H. 1973. The Sarus Crane (*Grus antigone*). In: Cranes of the world. Winchester Press, NY. Pp. 197-216.

Whitehead, C.H.T. 1911. Notes on the birds of Sehore, Central India, with special reference to migration. *J. Bombay Natl. Hist. Soc.* 21: 153-170.

Wood, T.C. and Krajewski, C. 1996. Mitochondrial sequence variation among the subspecies of Sarus Crane (*Grus antigone*). *Auk* 113: 655-663.

Xavier, N.K. 1995. Can a crane eat a crane? *Newsletter for Birdwatchers* 35(2): 38.

❑

Journal of Ecological Society Vol. 16 : 42-43 (2003)

Sarus Arrival In Chandrapur, East Maharashtra

*Atul Dhamankar**

Chandrapur, in east Maharashtra, indicates the southern-most point in the range of Sarus. Before 1990 Sarus crane was not studied in this part of its range. In 1993, I located a pair of Sarus on the banks of the wetland near a village called Junona, about 9 km from Chandrapur. We began to observe this pair and study their movements. A few days later we found a lone Sarus in the vicinity of Junona. I was fascinated by this lone individual. As Sarus cranes are normally found in pairs, this singleton aroused our curiosity. I made enquiries with the villagers about this Sarus. I was told then that in 1992 there were two pairs of Sarus on the wetland near Junona. One individual of the pair was shot down by a hunter-gatherer tribe. Since then this singleton is roaming around!

I continuted to observe the pair and the lone individual till 1997, when in October of that year, the pair disappeared. The next three months Sarus were totally absent. Then a lone Sarus came back and could be seen in remote corners of the wetland. We did our best to locate the nest of the Sarus crane, but we could not find one. Then suddenly a pair of Sarus appeared near the wetland. With them was a juvenile, with pale chestnut plumage trying to exercise its wings. Probably the pair might have constructed their nest in nearby fields.

In February 1999 we located another pair of Sarus on the outskirts of Tadoba-Andhari Project Tiger area, near a village called Moharli. It was also seen near a wetland. On one of the small islands in the lake, we also located the nest of the Sarus pair. It contained two eggs. This wetland is bordered on one side by cultivation and forest on the other side. The place is known for the movement of many wild animals especially at night. But we felt that the greatest danger to the nest of the Sarus pair came from the people who lived and moved around the wetland. We, therefore, contacted the officials of the wildlife department at Tadoba and apprised them of the existence of the nesting pair. We requested them to protect the nest. They agreed and appointed a forester to keep a watch on the nest. For the next 28 days the Sarus pair was busy incubating the eggs. On the 29th day, as the watchman had gone for lunch and was absent, someone pilfered the eggs. In another two or three days the eggs could have been hatched. The loss of eggs was very depressing. Thereafter, though the pair continued to visit the Moharli wetland, they never attempted to nest there. A pair of Sarus is also sometimes seen on wetlands around Itai dam reservoir which is not far from Moharli.

From our observation in Chandrapur district during 1998-1999 we concluded that 6 Sarus cranes could be found in the district. Four were around Junona and two around Moharli. We systematically surveyed the other parts of the district but could find no Sarus. Apart from Chandrapur we found Sarus in the Gondia district in Maharashtra, at a place called Singerbody. A pair was located there. In July 2003 we found a Sarus pair in the act of constructing their nest, in an agricultural field, near a village called Gudwa. One of the pair (probably the male) had an injured wing. In a couple of days we learnt that this injured bird was killed by some villagers!

We have been observing Sarus around Junona since 1993. In 1999 in the rear portion of the wetland at Junona, on an island a pair of Sarus had constructed

* Near Patel High School, Shivaji Chowk, Chandrapur 442402

their nest. It contained two eggs. One of this hatched but the chick succumbed to incessant rains which continued for days without a break. The other egg did not hatch and the pair then abandoned the nest. In October 1999 the pair again nested in a rice field. But the eggs were stolen and the Sarus left.

In 1997 a chick survived and grew up to eventually pair with the lone Sarus. The wetland therefore, harboured two pairs. The older seldom left the wetland while the new pair used to wander to other wetlands also. In August 2001 a pair again nested in the wetland but their eggs were also stolen. In the same month another pair nested in the rice field but after incubation progressed for a while, the nest was destroyed by the farmers. In February 2002 a pair nested in the rear portion of the wetland but the pair abandoned the two eggs after some days. This may have been due to greater movement of tourists and others nearby or use of pesticides in agriculture, making eggs infertile.

In July 2003 the male from the old pair got his leg entangled in a snare resulting in its death. The female did not take food thereafter, nor did it respond to medical treatment and died on 26th July. Now only one Sarus pair remains around the Junona wetland.

We have been constantly exerting ourselves to save the Sarus. In December 2001 we organised a campaign in Moharli and Junona exhorting villagers to protect the Sarus. We also visited all the villages on whose wetlands Sarus was sighted. In these villages meetings were organised and importance of Sarus was communicated. Slide shows, skits, exhibition of photographs were used to convey the message. We even arranged an Ornithologist's meet in Junona on 21st and 22nd December 2002 in which villagers participated along with bird scientists. The main theme was conservation of 'Sarus cranes in Vidarbha' (East Maharashtra). My studies show that since 1997 only one breeding attempt of Sarus cranes was successful when only one which survived. The main problem is pilferage. The villagers consider Sarus as sacred, call them Ram-Laxman (the legendary brothers from Ramayana), and do not kill them. Stealing of the eggs is all the more surprising therefore. The task of studying and trying to conserve Sarus has been handled only by the 'Wildlife Foundation' a non-governmental organisation. At the official level little support has been given to these efforts. The Irrigation Department of the government in July 2003 permitted the construction of a recreational complex on Junona wetland and had unwittingly constributed to driving away of Sarus.

Still two pairs wander around wetlands in Chandrapur district. A concerted effort by official and non-official agencies and individuals is needed to save them.

❑

Journal of Ecological Society Vol. 16 : 44-46 (2003)

Sarus Crane in Northern Myanmar, Kachin State

*Joost van der Ven**

'Status in E India and Myanmar uncertain . . .' citation from birds of the world, 1990. It is always interesting to visit the 'white spot' on the map. For long time the northern parts of Myanmar (Burma) were difficult to visit, especially Kachin state. I am definitely not the correct person to give an overview of the weal and woe of the Sarus crane (Grus antigone sharpii) in the nothern part of this country as my knowledge is only based on four winter visits. I agree, it is more than many others. In the Status Survey and Conservation Action Plan, The Cranes, IUCN 1996, the Sarus crane is not mentioned for Myanmar. Only for Pakistan-India-Nepal, G.a.antigone is mentioned. In a footnote the presence of the Sarus crane for Myanmar is mentioned without details as part of the population refound in Vietnam. It is in general agreed that the Myanmar birds belong to G.a.sharpii. In the most recent guide for the birds of SE Asia (C.Robson, 2001) the Sarus crane is mentioned as 'Formerly resident N Myanmar (current status unknown)'.

From November till April it is dry season in Kachin state as in nearly all parts of the country. A good time to visit the area but not the best time to see Sarus crane. Each observation of Sarus crane in his country is of great interest. From several sources recent information was received about several flocks in the delta of the Chindwin and Ayeyarwady, south west of Yangon. These will be breeding birds from that region and from other partsof Myanmar. As no Sarus cranes are breeding anymore (?) in Bangladesh or east-India, no birds come from that region. In former times this Burmese delta could have been a good wintering place for these cranes. One has to bear in mind that this delta area is very large and difficult of access though it is possible to visit the area by boat and there are some roads.

A few birds are always observed in Inle' Lake and some other wetlands in central Myanmar. As far as we know there is no general overview of the breeding places in this part of this country.

In the wet season it seems that the Sarus crane is breeding in many paddy fields and other wet areas in Kachin state. However, this is a statement by many local people and not verified by ornithologists. No information is available about arriving time in the breeding season or departure at the end of the season. The large paddy field areas east and south of Myitkyina and south of Mogaung seem to be excellent areas for the Sarus cranes. Many people informed us about breeding Sarus east of Myitkyina. We are only sure that these birds, if breeding in these areas, do not stay there during the dry season. In all these vast open areas where Eurasian cranes (*Grus grus*) and Bar-headed geese (*Anser indicus*) are wintering in good numbers, we never found any Sarus cranes during winter time.

In all paddy fields in the north, in wetlands and in overgrown oxbows we were looking during these four winters for them. In Kachin state we never observed them. In the north western part of Kachin state we were looking around Tanai. On most maps one will find close to this village the name Makaw. The habitat looks not very suitable for Sarus and no birds were found. There are only a few wetlands but most of paddy fields are dried out in winter.

The flat areas around Putao, in the far north of

* Joost Van der Verr, Brishkek, Kyrgyzystan

Kachin state, are covered by paddy fields. They are dry in winter. There are no typical wetlands suitable for Sarus. (We also looked for Black-necked cranes. Many areas looked exactly like the wintering sites in Bhutan but these cranes were not observed. Local people informed us also that they never observed cranes.)

In the southern part of Kachin state, around Bhamo, there are several oxbows of the Irrawaddy and small lakes and marshes. We did not find any cranes in that area. Most wet areas are used for growing vegetables and there seems to be no place for the cranes.

In fact there is only one area left in Kachin state. In the southwest of this state is Indawgyi lake. It is a remnant of a large inland bay cut off from the sea long ago. It has an absolute unique *Ichthyofauna* of which little is known. Already in the British time introductions of commercial fish took place without any ecological study, without studying the consequences for the original *Ichthyofauna* and without a long-term vision what to do.

This is not an isolated case as everywhere else in the world such irreversible introductions were carried out in the same way.

In former times there were vast marshes around the lake but most of them are now used as paddy fields. Some marshes remain in the north-eastern parts above the lake. They are situated along the river outlet of the lake, the Chaung Wa. Nowadays they are part of the nature-reserve but their management till now is not impressive. The paddy fields are in winter completely dry. It really made our day when we found for the first time Sarus cranes in the wetlands around the lake.

In 2000 we did not see them; in 2001 we found seven birds; in 2002 we found eight birds and none in 2003. However, another ornithologist visited the lake in 2003 a few days later and found several Sarus cranes in the marshes. Among the birds we found two or three juveniles. They stay in families but not in one larger group. Single birds or a pair without juvenile(s) can be observed.

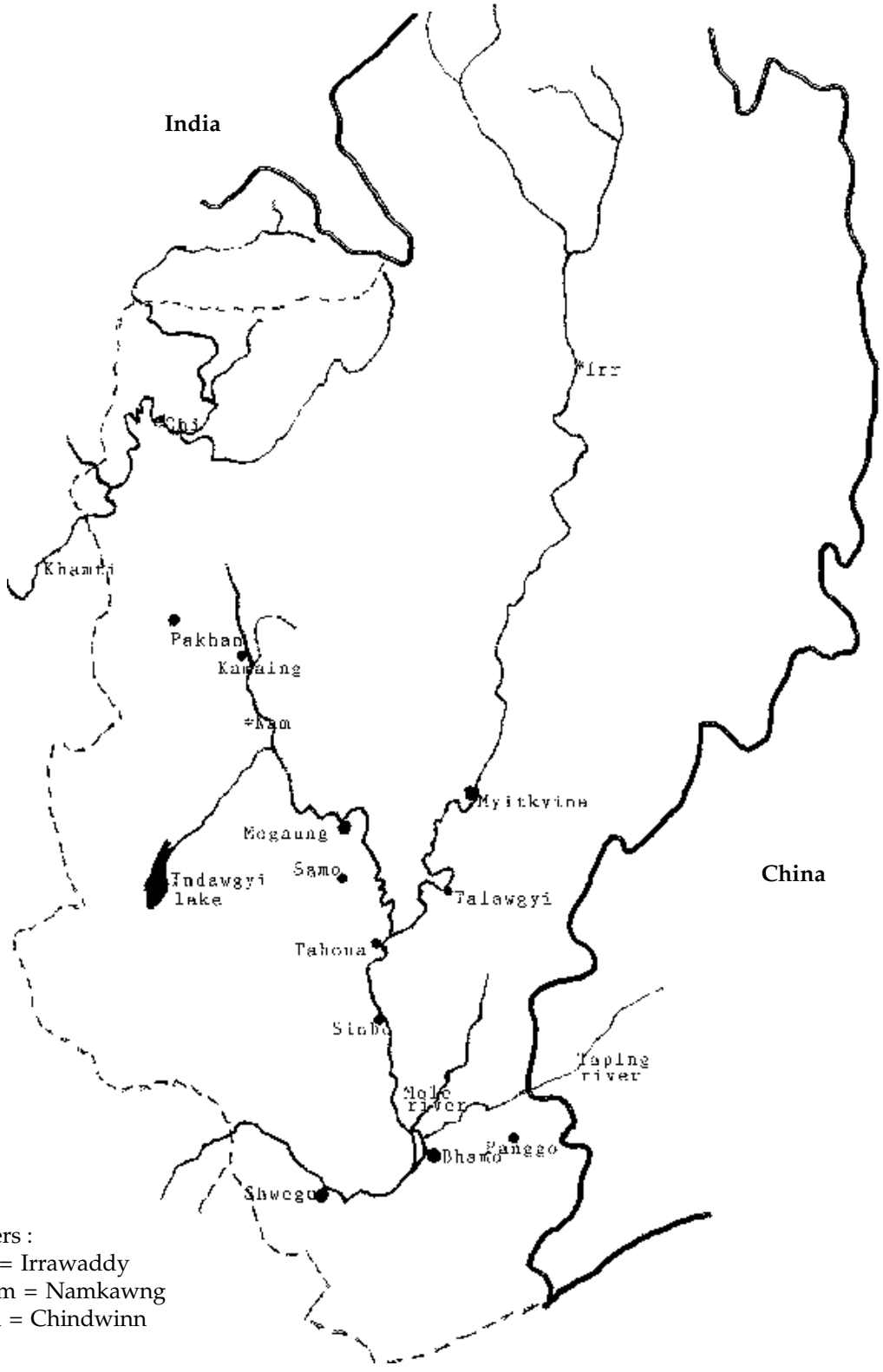
It is not always easy to find the cranes. When one is using the boat over the Chaung Wa, it is difficult to see the surrounding marshes. One should be lucky when the cranes are close to the stream. If they are deeper in the marshes and into the high vegetation, one will not see them. They are not very noisy in this time of the year.

Another favourite area of the cranes are the remaining marshes along this river after the village of the same name. The winding river flows north-east through an area with very high banks (upto 5 metres) and mainly agricultural (vegetable) fields. There are remaining wetlands fully overgrown and some open water where the cranes feed. We also found Sarus cranes in the dry paddy fields west of the lake. This only happened once and these areas are probably used in combination with other areas. There are several other areas around the lake where cranes were seen or just were flying over. There might be other feeding grounds not known by now.

In principle it might be possible that these cranes are breeding in wet areas within Kachin state and winter only in the lake. This is not logic as birds are observed here during the entire year. It is supposed that 2-4 pairs of Sarus are breeding in this area and the birds are non-migratory. There might be exchange among cranes in the wet season when other cranes will stay in the surroundings for breeding in areas mentioned above. For these cranes there is no need to migrate to the south as long as the numbers are small. It is urgently needed that next to the protection of Indawgyi lake itself, more attention will be given to the surrounding marshes. The agricultural uses of these areas is a serious threat for all breeding birds. Resting places for birds other than geese and duck are limited and not secure. In the winter period cranes have to share the limited areas with Lesser Adjutant (*Leptoptilos javanicus*), Open-billed stork (*Anastomus oscitans*), Painted stork (*Mycteria leucocephala*) and Spotbilled Pelicans (*Pelecanus philippensis*) and numerous herons next to attentive birds of prey, like White-tailed Sea Eagle (*Haliaeetus albicilla*) and Greater Spotted Eagle (*Aquila clanga*). As on many other places the Sarus cranes follow their own way and seem to be little disturbed. Till the date will come that they are suddenly disappeared becaused we disturbed them too much and neglected their modest desires.

❑

North Myanmar
Kachin State



Rivers :
*Irr = Irrawaddy
*Nam = Namkawng
*Chi = Chindwinn

Journal of Ecological Society Vol. 16 : 47-48 (2003)

Sarus Cranes : An Emblem of Failure of India's Conservation Movement?

Lavkumar Khacher

For quite sometime I had considered the presence of Sarus and Peafowl, freely and fearlessly sharing the most densely populated areas on Earth, as proud emblem of Indian civilisation. Unhappily, as I developed greater maturity in conservation thought and corresponding insights into trends developing across the land, I began to suspect a perceptible drift towards a massive extinction of all animals. I began contemplating the nebulous fears which prevented my joining in the applauding groups extolling India's great progress on the environmental front notwithstanding the many prestigious protected areas declared, the participating of the nation in international seminars and treaties evolving from them, and the large numbers of N.G.O.s all blowing conservation bugles. As before, in the widespread awareness and activism for environment protection, today I stand isolated from the mainstream; the loneliness today being worse than before. I find myself questioning those of my own ilk! The very first time I realised that the path ahead would be lonely was at the international crane meet at Bharatpur in 1987. I had already started doubting the continued security of the Sarus crane and expressed my fears to a doubting gathering, many of whom were my friends. My regret today is that I was not more aggressive and had not faced the sceptical audience more forcefully even at the risk of open ridicule.

While everyone were applauding the Rajasthan government for showing 'great political will' to the extent of having fired on cattle owners insisting on maintaining their grazing rights in the Keoladeo Ghana National Park, I saw those shots as being fired against Indian traditions which had permitted highly visible birds like the Sarus to fearlessly live among human beings as nowhere else except in Buddhist Tibet, and Bhutan. At that fateful meet, I had, now in hindsight, rather timorously pointed out that the high concentration of breeding pairs of Sarus in the Ghana wetland pointed to a withdrawal from the surrounding countryside. I am afraid, my image of being inimical to Forest Departments seemed to have been justified. Ahead lay a path of isolation. Today, the Sarus crane is as surely on the inexorable path into oblivion as is much of the region's dramatic wildlife. The tragedy is that this would never have happened had we, the conservationist lobby, been more aware of the intrinsically civilising values of traditional Indian thought as against high reliance on the new and much overrated wildlife legislation that is smothering any meaningful initiatives by concerned individuals. The time has now come to reassess the limits of government capacity within the present day, democratic milleu prevailing in India.

The Sarus, so large and visible, should have been lost a long time ago had it not been for a strong, popular sanction - call it 'taboo' - against harming it in any way. This goodwill still exists and if modern conservation practices are grafted onto traditional attitudes, we may still have the evocative call of the great crane proclaiming India as a unique example of how human welfare need in no way be detrimental to conservation of the wilderness. Since the Sarus cannot be isolated into designated protected areas, a Sarus conservation initiative may refurbish the mesh of India's wilderness enriching the lives of the population at large. Sarus cranes are linked with the spark of com-

* 14 Jayant Society, Rajkot 360004 / 646 Vastunirman, Gandhinagar 382022

passion that became a conflagration through the teachings of Buddhism, Jainism and Vaishnavism. It is believed that the great Rishi Valmiki uttered his first 'shloka' in Sanskrit as he watched a bereaved Sarus whose mate had just been killed by a hunter. From that day on, the fidelity of Sarus couples and the pining away of the survivor has led to a firm conviction that killing of one of the pair brings down great misfortune on the hunter. So widespread was the belief that the Sarus stalked through Indian history rarely molested by human beings. Even during the great duck shoots of colonial times, blazing guns left the Sarus serenely indifferent to the carnage around them! Over a wide swathe of territory across the present day states of Gujrat, southern and eastern Rajasthan, Haryana, Punjab and east through Uttar Pradesh across the wide flood plain of the Ganga into the Brahmaputra valley of Assam these great birds throve.

Breeding, as they do, during the month of monsoon deluges and widespread inundation, the nesting pairs were little molested. For so large a bird nesting on the ground among marsh vegetation the moot critical period is when eggs are incubated and for a brief time after hatching when the fluffy chicks are vulnerable to snakes, monitor lizards, wild or feral cats and jackals. In former times when larger predators like tigers and leopards were more widespread these too must have added to the danger as indeed must have the sounders of the wild boar that were till recent times rather plentiful in the cranes' preferred habitat. The continual vigilance of the large parents augmented by considerable ferocity in defending the nest and young, no doubt greatly reduced predation and in the initial stages, the inexorable spread of human activity with decline of large predatory animals during the 19th and earlier half of the 20th century would have improved breeding successes. The optimum, however, was quickly reached and surpassed. The initial adverse impact of increased conversion of wetlands into rice fields had started to impact on cranes in Bihar, Bengal and the Brahmaputra valley in Assam.

Actually, in the eastern part of Sarus range, the huge expanses of monsoon inundation effectively provided immunity to nesting pairs. The social taboos against harming the birds were less pervasive than they were in western parts. As the wetlands got converted into paddy fields these areas available for breeding pairs rapidly dwindled and if the crane were able to hold out, it was more on account of their wary disposition that prevented hunters from getting within harming range. It was in western Uttar Pradesh, Haryana and south across the Mewar region of Rajasthan into Gujrat that the Sarus enjoyed the fullest of security conspicuously nesting in the midst of intensive agriculture wherever a depression collected water in the middle of which to put together the bulky nest platform. Road and rail side ditches were other favourite locations.

In Gujrat, rural folk refer to a crane pair in the vicinity as the 'Beladi' or the 'couple'! With human beings posing no danger, the cranes were quire able to keep off intruding domestic animals by posturing threateningly, and smaller intruders were aggressively attacked. That the crane population has declined under seemingly favourable conditions is because of factors which we should have been forewarned of decades ago. I remember pointing out that fewer and fewer pairs had two juveniles tagging along, indicating that habitat shrinking had set in. Many friends who have been very actively monitoring breeding pairs in Kheda and areas around Ahmedabad have reported larger and larger number of pairs failing to raise a single chick. In short, the situation is alarming.

On the other hand, wetlands are getting constricted so that foraging areas for growing chicks are considerably reduced, worse still is something which never happened before - with the fragmentation of landholdings farmers are growing less tolerant of a pair constructing a bulky nest of uprooted vegetation which, as often as not, is young paddy. While the adults are not harmed, they are discouraged from taking up residence. Once the symbol of good fortune, a nesting pair of Sarus is being increasingly viewed as an economic liability! More pervasive, however, is the fact that farmers have taken to using inorganic fertilisers and pesticides in a big way so even if a pair is permitted to lay, either there are failures in hatching or there is not enough protein food available for healthy growth of the chicks. The scenario cannot be more gloomy. Very serious thinking needs to be gone into to mobilise public concern and full involvement in a sustained project to ensure that the remaining, ageing pairs lay full clutches and raise both chicks. If need be, one of each hatchlings should be raised in captivity as has been so successfully done with the highly endangered Whooping Cranes of North America. We in India have an assured chance for a great success story because our cranes, unlike American Whooping crane, are resident and do not undertake long distance migrations with all the dangers they entail. Involving the people and playing on traditional values for compassion towards all living creatures seems the best approach.

❑

Journal of Ecological Society Vol. 16 : 49-51 (2003)

Krauncha and Sarasa in Sanskrit Literature

*Suruchi Pande**

The sixth Dalai Lama said
''If only white cranes,
Do grant me wings;
I shall not go far;
Only to Lithang, then home.''

He promised this to his love but he never returned. We come across similar praise of cranes in other literature as well.

In many countries cranes and Sarasa cranes were pet birds. In Australia, the fascinating dance of Brolga forms the basis of aboriginal dances. In Chinese legend the crane was a bird ridden by immortals. It symbolizes happiness and longevity. Many Chinese emperors liked to keep cranes and enjoyed literary pieces depicting them. In the Jaina religion it is believed that the symbol (लांच्छन) of fifth Tirthankara – Sumatinatha is the crane. In the Buddhist literature the crane is found in mystical context. It is one of the birds that meditated on the discourse of the Buddha. The Great Crane expressed highly philosophical thoughts. It said,

'One must observe unsullied moral purity
as the root of all dharmic action.
One must observe the need to abandon
whatever belongs to this world,
and that includes
the bonds of life in the various heavens.
One must observe that indolence and
sloth hinder the doing of good.
One must observe that the demons of meanness
hinder generosity.
Let these things also enter well into your minds.'

Sometimes the references to cranes (Krauncha) and Sarasa in Sanskrit literature create confusion because rarely the descriptions of 'Krauncha' point to the Sarasa crane. The word Sarasa (सारस) is to be derived from the word 'Saras' (सरस्) meaning 'the lake'. This word is not found in the Rigveda, but is seen in the Vajasaneyi Samhita and in the Brahmana text.

A) Cranes

Oldest references to the crane (Vedic period)

. . . . इन्द्राग्निभ्यां क्रुञ्चान्मित्राय मद्गून् . . . ॥
– Vajasaneyi Samhita

= Let the crane be offered to Indra and Agni.

वागात्मकं खलु क्रौञ्चं साम ।
– Tandya Brahmana

= Indeed, the Sama called Krauncha is of the nature of speech.

Etymology and Synonyms of the Crane

The word 'Krauncha' appears to have been derived from the root verb Krunc- (1p) 'to call, to make sound'. The Amarkosha gives a synonym 'Krun-' derived from the same root. The Abhidhanachintamani text gives the etymology of the word 'क्रुञ्चति क्रौञ्चः ।' = Krauncha is one that gives out calls.

Mythological reference to the crane

In the Skanda purana, there is a story about a demon namely Krauncha. This demon took the shape of a mountain and hindered the way of Sage Agastya. Lord Subrahmanya pierced him with an arrow.

* C-9 Bhosale Park, Sahakarnagar No. 2, Pune 411009, Phone : 24221345, e-mail : suruchipande@hotmail.com

Reference to augury

The 'Vasantarajashakunam' text describes augury in relation to the crane.

इष्टार्थसिद्धिः सकलासु दिक्षु ससारसद्वन्द्वविलोकनेन।
श्रुत्वास्यपृष्ठे निनदं न गच्छेत्सिद्धत्यभीष्टं गृह एव यस्मात्॥

= 'If a pair of (Sarasa cranes and) the cranes is seen in every direction you will accomplish whichever is desired. If its call is heard at the backside then one should not go out as one's desired object is obtained at home.'

Description of cranes in epic and classical poetry

Sage Valmiki saw a pair of cranes moving about in the forest, never parting from one another and making a charming noise. A hunter killed one of the pair of birds and he was cursed by the sage. Valmiki was inspired to compose the Ramayana, when he saw a female bird wailing.

वियुक्ता पतिना तेन द्विजेन सहचारिणा।
ताम्रशीर्षेण मत्तेन पत्रिणा सहितेन वै॥

– Ramayana

= '(A female bird lamented as) she was parted from her mate and companion, the bird, that was endowed with a coppery head was inflated with passion and courting had distended its wings.'

From the description of the bird – the Krauncha here – must be the Indian Sarasa crane since it is the commonest resident and breeding crane in India.

In the Meghaduta of Kalidasa there is a reference to the 'Krauncharandhra' (the gate of the cranes) in the Himalaya.

Strategic formation of infantry

One of the strategic formations of infantry is known as 'Kraunchavyuha', which has eight strategical positions.

Superstition regarding the crane

ज्येष्ठं पितृसमं चापि भ्रातरं योऽवमन्यते।
सोऽपि मृत्युमुपागम्य क्रौञ्चयोनौ प्रजायते॥

– Mahabharata

= 'One who insults the elder brother – equal to one's father, is born as the crane after one's death.'

Reference to the crane in Indian music and prosody

पदैः स्वरैः क्रौञ्चपदः प्रतितालेन गीयते।
स्वरन्यासः स तन्नाम्ना छन्दसा मुक्तकोऽथवा॥

– Sangitaratnakara

= 'A group of musical notes namely – kraunchapada is sung with the help of Pada and Swara. It is in the same metre known as 'Kraunchapada' or is in the free metre.'

Reference to the crane in Ayurveda

अस्याऽस्थि मूत्रदोषहरम्।

– Sushruta-Uttarasthana

= The bones (of the crane) are useful in curing urinary problems. (Today such references may best be disregarded in the presence of better and proven medicines. – author)

Description of cranes in the Mrigapakshishastra

नितरां दीर्घपादाश्च दीर्घचञ्चुपुटद्वयाः।

= '(Cranes) have long legs and long beak.'

B) Sarasa Cranes

Synonyms of the Sarasa crane

. . . रक्तमूर्धा . . . सारसो लक्ष्मणोऽपि सः॥

– Kosha Kalpataru

= 'The head (of the Sarasa crane) is red. It moves about in water, so it is called Sarasa. It is called Lakshamana because it has a particular mark (lakshama).'

Mythological reference to the Sarasa crane

In the Mahabharata the Sarasa was said to be the son of Garuda (eagle).

Description of the Sarasa cranes in Sanskrit poetry

श्रेणीबन्धाद्वितन्वद्भिरस्तम्भां तोरणस्त्रजम्।
सारसैः कलनिह्रदैः क्वचिदुन्नमिताननौ॥

– Raghuvamsha of Kalidasa

= ''At times raising up their faces at the Sarasa birds, who sweetly warble, and, by flying together in a line seemed to form a garland at the archway without supporting pillars.''

Reference to the Sarasa crane in Ayurveda

पक्षी, प्लववर्गीय, अस्याऽस्थि कफजमूत्रकृछ्रे उपयुक्तम्।

– Charaka-chikitsasthana

= '(The Sarasa crane) is an aquatic bird. Its bones are useful in urinary problems.'

Description of the Sarasa crane in Mrigapakshishastra

मृदुस्पर्शाश्च नितरां प्रायः कलरवा मताः।
जलवासैकनिरता नयनानन्ददायिनः॥

= '(The Sarasa cranes) are very soft to touch and (their) call is melodious. (These) aquatic birds give pleasure to the eyes.'

Sanskrit literature views cranes in various perspectives. References to migratory routes and mountain passes used by birds are encountered in Sanskrit lit-

erature. Sanskrit continues to play an important role in life, thought and expression of Indian people. It is a window to our ancient knowledge and it is necessary for us to understand our compassionate heritage.

Several birds feature in the Sanskrit literature. The cranes appear to have made a distinct impact on the ancient Indian mind. A few examples are cited in the present text. The cranes continue to do so even today. The reduction in the numbers of the cranes is therefore all the more distressing. More than ever, it is most necessary that we now imbibe the nobel tradition of conservation and compassion towards all wild life. That is the only hope.

❑

Sustainable Management of Natual Resources and Nature Conservation

A One Year Certificate Course Through Correspondence

Eligibility : A Graduate in Arts, Science, Commerce, Engineering, Medical etc.

Admission : on any day of the year

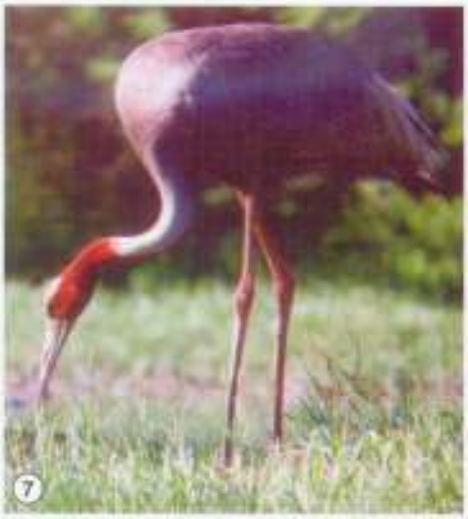
Fees : Rs. 1500/- at the time of admission
Rs. 600/- six months after admission
Rs. 500/- at the end of the year

Medium : English or Marathi

Correspondence : Articles, notes and other material relating to the course will be sent by post

Students will be asked to submit their assignments through post. (There is no examination. Assignments will be evaluated for the award of certificate.)

Address for Correspondence, payment of fees and submission of Assignments :
Prakash Gole
Director, Ecological Society
B/2 Jayanti Apts.
Senapati Bapat Road
Pune 411016
Tel. 25677312



1. Indian Sarus : Gopi Sundar
2. Eastern Sarus : J. A. Van der Ven
3. Indian Sarus : International Crane Foundation
4. to 10. Indian Sarus : Prakash Gole