NEST AND EGGS OF SARUS CRANE (*GRUS ANTIGONE ANTIGONE* LINN.)

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Abstract

Between 1996 and 1998, Sarus Crane (*Grus antigone antigone*) nests were examined during the breeding season in Kheda District, Gujarat. During this period 70 nests and 136 eggs were measured and described. The nests were mainly located in non-cultivable agricultural marshland. The nesting materials reflected the dominant plant species in that locale. Water level influenced the nest height as well as the use of nesting material. A strong attachment was noticed in terms of nest-site fidelity. The clutch size was two (n = 68), however one information on clutch size of three was known only after the hatching of the eggs. Eggs in the same clutch showed significant difference (P < 0.01) in length and weight. Infertile eggs were slightly longer than viable eggs.

Keywords

Sarus Crane, agricultural marshland, Kheda District, Gujarat, nest, nesting material, egg ,
Grus antigone antigone

Introduction

Nest site selection involves the specific choice of a site to build a nest, and in marsh nesting birds it usually occurs just prior to egg laying (Cody, 1985). Proximate cues in general habitat selection may involve tradition for species with fidelity (Bongiorno, 1970); pressure from conspecifics or protector species, and physical features. Marsh nesting species can nest only when the physical environment is suitable (Tinbergen, 1960; Berger, 1974).

The Sarus Crane (*Grus antigone antigone*) is basically a wetland bird and prefers nesting in marshland (Ali & Ripley, 1983; Walkinshaw, 1973a; Gole, 1987). In Kheda District, Gujarat, the cranes have occupied agricultural landscapes (Parasharya *et al.*, 1996) by tracking habitat changes (Mukherjee *et al.*, In press a). An alarming decrease in crane distribution range and population has been noticed in the last decade (Gole, 1989; 1991; Parasharya *et al.*, 1996; Mukherjee *et al.*, In press a, In press b). It has been recently categorised as a globally threatened species (Meine & Archibald, 1996). This paper summarizes information of nest-site characteristics, nesting chronology, clutch size and various egg morphology that was obtained during our annual field visits in 1996, 1997 and 1998.

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Materials and Methods

Breeding ecology of the Sarus Crane was studied in Matar, Thasra, Petlad and Khambhat Tahsils of Kheda District, from 1996 to 1998. The breeding season is defined as the period between the initiation of the first clutch and the last clutch in the population (Campbell & Lack, 1985). The breeding season of the Sarus Crane in northwestern India and particularly in Kheda District, coincides with the South-West monsoon (Ali & Ripley, 1983; Parasharya *et al.*, 1989; Mukherjee, 2000). Most of the nests were located during the stage of nest building or early stage of egg laying. Intensive nest searching was done every week during July to October moving through the study area on different routes. Since Sarus Crane nest in areas inaccessible to ground vehicles, the nest site was approached on foot. During nest visits, both the nest and the eggs were examined, photographed and egg viability tests were conducted. Nests were measured to the nearest centimeter and other affiliated parameters like water depth were measured. The eggs were numbered using permanent marker to note the sequence of hatching. The eggs were weighed using Pesola spring balance (300g ± 2.0g sensitivity); egg diametric details were recorded using plastic vernier caliper (0.01cm least count); viability tests were performed by means of immersion of egg in normal water (30^0-35^0C) (Kuyt, 1995). These tests indicated whether the egg contained a viable embryo and also the incubation stage. However, the incubation stage was generally known from observed laying dates assessed during repeated field visits. In other cases, the dates of clutch initiation were either inquired from the farmer or were extrapolated by deducting 31 days incubation period (Gabel & Mahan, 1996) from the date of hatching.

For performing statistical analysis, the habitat was further classified broadly into two categories, viz. (I) agricultural marshland and (II) non-agricultural marshland. Both the habitats were further classified into eight microhabitats on the basis of hydrological, topographical and economical features of the microhabitat. They are listed as (I): (1) Paddy field bund (2) Within standing paddy crop; (II): (3) On bund (4) Marshy agricultural waste land (5) Khet-talavadi (6) Canal seepage (7) Reservoir, and (8) Village pond.

Table 1. Distribution of Sarus Crane nest in different microhabitats of agricultural landscape during 1996-1998

Microhabitats	Nests seen 1996-1998 Fi	%O
I Agricultural marshland	68	97.14
(A) Paddy cultivated area	30	42.85
1. Field bund	26	37.14
2. Within standing crop	4	5.71
(B) Non-cultivable land	38	54.28
3. On bund	8	11.42
4. Marshy wasteland	18	25.71
5. Khet-talavadi	7	10.00
6. Seepage canal	5	7.14
II Non-agricultural marshland	2	2.85
7. Reservoir	2	2.85
8. Village pond	0	0

Results

Nest

Nest site selection

The Sarus Crane nested either in agricultural marshland or in non-agricultural marshland (Table 1). Within the marshy area, elevated spot in the accumulated water was chosen for nest building. The nest was a platform of varying size, usually made using aquatic vegetation. The nest base was broad, submerged in water. Top view of the nest at water surface level was round or oblong. The central portion of the nest was always slightly depressed and lined with soft green material which was added by the parent bird throughout the incubation period. The green material was pulled from the marshy area and the central part of the nest was intentionally kept wet. There was annual variation in the distribution of nests in different micro habitats (X^2 = 42.5, *d.f.* 7, $P < 0.05$). During 1996, all 26 nests were recorded in agricultural marshland. The distribution of Sarus Crane nests between paddy cultivated area and non-cultivable agricultural marshland was statistically non-significant. The proportionate area of paddy cultivated land and non-cultivable agricultural marshland was 0.88 and 0.12, respectively. When the nest distribution in these two microhabitats was compared with reference to the proportionate availability of these microhabitats, it was clear that non-cultivable agricultural marshland was preferred over paddy cultivated area, using the selectivity index (Ivlev, 1961). The selectivity index of paddy crop area was -0.21 indicating that nest distribution in this microhabitat was slightly less than its proportionate availability. On the other hand, selectivity index of non-cultivable agricultural marshland was +0.56 indicating a preference of this area for nesting.

During 1997, 31 nests were recorded in agricultural marshland. The non-agricultural marshland had only two nests, thus the distribution of Sarus Crane nests between paddy cultivated area and non-cultivable agricultural marshland was statistically significant. When the nest distribution was compared to the proportionate area of paddy cultivated land (0.84) and non-cultivable agricultural marshland (0.16), the latter was preferred. Further, the selectivity index of paddy crop area was -0.4 indicating that nest distribution in this microhabitat was proportionate to its availability. On the other hand, selectivity index of non-cultivable agricultural marshland was +0.6 indicating high preference of this area for nesting.

During 1998, all the 11 nests were recorded in agricultural marshland thus the distribution of the Sarus Crane nests between paddy cultivated area and non-cultivable agricultural marshland was statistically non-significant. The proportionate area of paddy cultivated land and non-cultivable agricultural marshland was same as 1997. When the nest distribution in these two microhabitats was compared with reference to the proportionate availability of these microhabitats, it was clear that non-cultivable agricultural marshland was preferred. The selectivity index of paddy crop area was -0.51 indicating that nest distribution in this microhabitat was slightly less than its proportionate availability. Selectivity index of non-cultivable agricultural marshland was +0.64 indicating high preference for nesting.

When over all scenario of 1996, 1997 and 1998 was compared, the results revealed that out of the total 70 nests monitored, 68 nests were recorded in agricultural marshland. The distribution of Sarus Crane nests between paddy cultivated area and non-cultivable agricultural marshland was statistically significant. Within paddy cultivated area, maximum nests were on bund compared to the nests within the standing crop. The proportionate area of paddy cultivated land and non-cultivable agricultural marshland was 0.86 and 0.14, respectively. When the nest distribution in these two microhabitats was compared with reference to the proportionate availability of these microhabitats, it was clear that non-cultivable agricultural marshland was preferred over paddy cultivated area. The selectivity index of paddy crop area was -0.33 indicating that nest distribution in this microhabitat was proportionate to its availability. On the other hand, selectivity index of non-cultivable agricultural marshland was +0.57 indicating a preference for this area for nesting.

The overall picture showed that 97.14 per cent nests were distributed in the agricultural marshland compared to only 2.5 per cent nests in non-agricultural marshland. Amongst the agricultural marshland, the preference for paddy cultivated area (42.85%) and non-cultivable land (54.28%) was almost equal ($X^2 = 1.06$, $d.f. = 1$, $P > 0.05$). Within agricultural marshland, the crane showed preference for non-cultivable land. Even though the banks of village ponds were marshy, they were never utilised for nesting.

Nest material

Specimen of each nest materials from 60 nests were collected and identified. Besides using green plants from the surrounding area, dried roots of *Oryza sativa*, straw of *Pennisetum typhoides* and rhizomes of *Cyperus rotundus* were used. Such dried material was used and arranged in 0.9m² central area of the nest. Amongst the green material used for nesting, frequency of *Ipomoea aquatica* was highest (45.00%) followed by *O. sativa* (36.67%) and *Cynodon dactylon* (36.66%). Other nest material like *Typha angustata, Cyperus rotundus, Echinocloa colonum* and *Digitaria sanguinalis* were recorded in lesser frequency (Table 2). For nest building, at least 23 species of fresh aquatic plants were used. However, depending on the type of microhabitat and time of nest building, dried parts of four plant species were used. For nest building, the material was always collected within 16m radius of the nest.

Collection of the nesting material was always done from the nearby area (Table 3). Amongst the nest found in agricultural area, 60.86 per cent of nest had *C. dactylon* and 52.17 per cent nests had *O. sativa* as the major nesting material. Nest built in microhabitat 3 and 4 had *I. aquatica* and *Scirpus littoralis* as dominant nest material while nest found in microhabitat 5, 6, and 7 were made up of bouyant materials like *T. angustata, I. aquatica* and *S. littoralis.* Thus it is clear that the nesting materials used depended on its availability in the concerned microhabitat. Diversity of plant material used in microhabitat 4 was highest (16) followed by agricultural area when the nest was on bund (14) and least (2) when the nest was located within the crop field (Table 3).

Table 2. Nest material and its frequency in the Sarus nest.

Botanical name	Nest material Fi	% O
1. *Oryza sativa*	22	36.67
2. *Echinocloa colonum*	8	13.33
3. *Cynodon dactylon*	22	36.67
4. *Ipomoea aquatica*	27	45
5. *Ipomoea carnea*	5	8.33
6. *Typha angustata*	18	30
7. *Digitaria sanguinalis*	9	15
8. *Cyperus rotundus*	18	30
9. *Argemone mexicana*	3	5
10. *Commelina benghalensis*	3	5
11. *Kirganelia reticulata*	1	1.67
12. *Eichhornia crassipes*	1	1.67
13. *Scirpus littoralis*	8	13.33
14. *Marcelia* sp.	1	1.67
15. *Hydrilla verticillata*	3	5
16. *Nymphoides indica*	2	3.33
17. *Najas graminea*	5	8.33
18. *Paspalum distichum*	9	15
19. *Oryza rufipogon*	2	3.33
20. *Limnophyton obtusifolium*	2	3.33
21. *Eleochharis duleis*	1	1.67
22. *Digitaria ciliaris*	1	1.67
23. Roots of *Oryza sativa*	3	5
24. Roots of *Typha angustata*	1	1.67
25. Stem of *Pennisetum typhoides*	1	1.67
26. Stem of *Sorghum bicolor*	1	1.67
27. Tuber of *Cyperus* spp.	7	11.67
28. Unidentified leaf	1	1.67

n = 60

Table 3. Predominant vegetation (% Fi) used as nesting material with respect to different microhabitats.

Vegetation	Microhabitats						
	1 (n = 23)	2 (n =3)	3 (n = 8)	4 (n = 4)	5 (n =5)	6 (n = 5)	7 (n = 2)
Oryza sativa	52.17	100	50		40		
Cynodon dactylon	60.86		37.5	21.43	40		
Ipomoea aquatica	34.78		62.5	50	60	60	50
Echinocloa colonum		33.33				20	
Typha angustata			37.5	42.86	60	100	50
Cyperus spp.			37.5	42.86	20		
Scirpus littoralis				50			50
Hydrilla verticillata				21.43			
Digitaria sanguinalis						20	
Ipomoea carinia							50
Diversity	14	2	14	16	9	5	4

Nest building

The Sarus Cranes started nest building activity just two or three days prior to egg laying. Both the sexes participated in the collection of the nesting material. The fresh vegetation from the adjoining area of the nest site was uprooted/cut for nest building. Hence, a cleared area surrounding the nest was observed. Preparation of the nest platform required only 48 hours. In some cases, addition of material to the nest platform continued even after egg laying. Nest amendment continued throughout the incubation period. However, the cranes quickly added fresh nesting materials to increase the nest height in response to a sudden increase in water level. Often the eggs were laid on readily available heap of fresh grass. The weed removed from the field and piled up on the bund was often used as nest platform. Hence, the cranes did not make any additional effort to collect the nesting materials. Both the sexes involved themselves in nest building activity. Either of the sexes pulled or uprooted the nesting materials, throwing it towards the nest site by a sideways jerk of the neck. The other partner collected the nesting materials and arranged to build the nest platform. The dry hollow straw floating on water was transported to the nest site by pushing it with the bill in a few steps to the nest site. During incubation the female did not engage herself in cutting the nest material but the male performed this task. However, the female arranged the nest material even while incubating.

Nest amendment

The nest amendment activity was recorded during our repeated visits to the nest. Fresh nest material was also recorded in nests with eggs and in a few nests with a chick. During incubation either of the sex did nest amendment activity. While on nest, the incubating bird periodically stood up on the nest for egg rolling and also performed amendment activities. Amendment activities were also observed during change overs for incubation. Prolonged amendment activities were generally observed during late evening when both the sexes were near the nest. The nest amendment activity was observed in one nest where male was collecting the nesting material and transferring it to female standing on the nest. She arranged the material on nest whereas the chicks were hiding in the nearby vegetation.

Nest diametrics and water depth requirement

Nest diametrics of 56 nests were measured for further analysis. The statistical analysis was done to test differences in nest diametrics and water depth requirement. Results show that there was no significant difference in nest length in different microhabitats, however the nest breadth varied significantly amongst the microhabitats (F = 4.79, $d.f.$ = 5.50, $P < 0.05$), (Fig. 1). Maximum nest breadth was found in marshy wasteland. Nest height above water surface (H1) did not differ significantly amongst the microhabitats. However, the total nest height (H2) measured from the ground varied significantly. Minimum nest height (41.0cm) was recorded in paddy fields while maximum nest height was recorded in the seepage canal (95.67cm).

Certain water depth was a prerequisite for the nest site selection. Mean water depth around the nest varied from 24.75cm in paddy crop area to 65cm in the seepage canal (Fig. 1). Floating nests were usually recorded in the non-cultivable land particularly marshy wasteland, *khet-talavadi* and seepage canal, where the

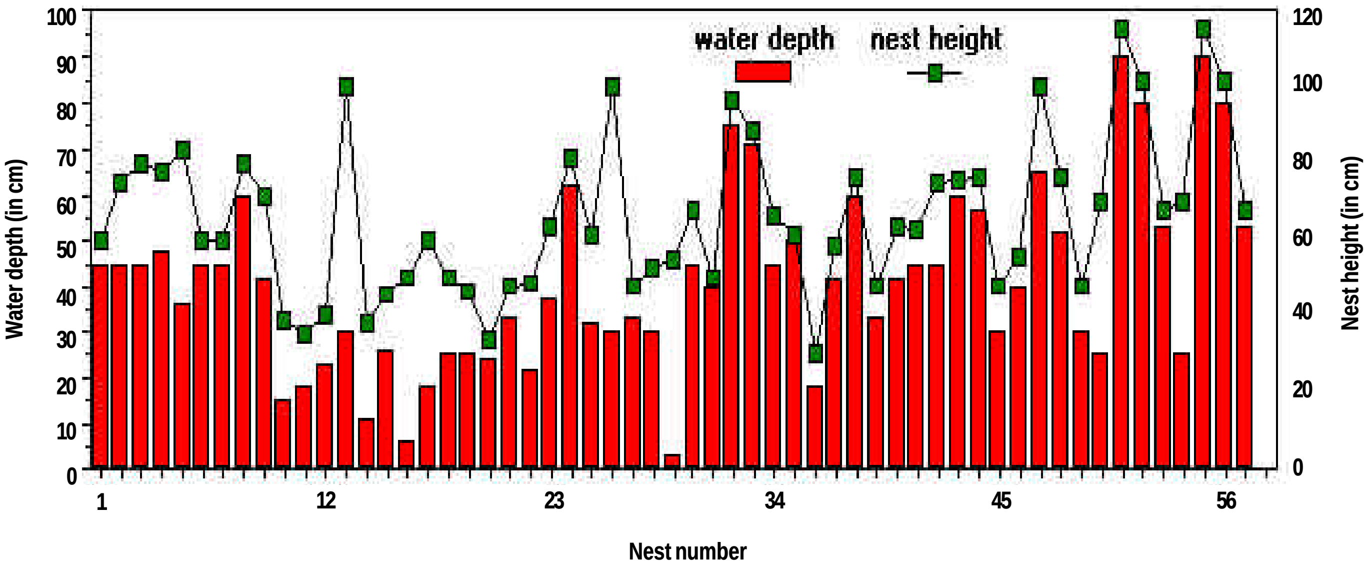

Figure 1. Influence of water depth on nest height.

water depth was relatively higher. The floating nature of the nest was chiefly attributed to higher water depth in that particular microhabitat and the type of nesting material used.

Nest height and water depth

A strong positive correlation was established between water depth and the total nest height ($r = 0.78$, $d.f. = 28$, $P < 0.05$). The reliability of the regression equation ($Y = 32 + 0.814 X$) worked out was 62 per cent (Fig. 2). Due to the influence of some of the microhabitat like *khet-talavadi* (5), where the cranes nested on slightly elevated land, showed poor correlation of the water depth requirement against nest height. Such nest characteristics reduced the dependency of the correlation established.

Nest site fidelity

Sarus Cranes display a strong attachment to the previous year's nest site. Successive nests were located in the same area of the marsh, as is also reported for Whooping Cranes (Kuyt & Goossen, 1987; Kuyt, 1993). Our observations and inquiry from the local villagers revealed that, in several places the cranes have nested on the same site since more than five years. Even after the destruction of first clutch, the Sarus Crane preferred to renest almost near the original nest site. Thus it was revealed that unless disturbed seriously, the crane did not change the nest site.

Extra nest platforms

Atleast seven pairs had an extra nest platform (during 40 days period) within 20m radius of the original nest site after hatching of their chicks. One pair which nested in the paddy field near Narda Reservoir during 1996, had made four extra platforms. These new platforms were at 10-15m distance from each other within inundated paddy field. Probably the extra platforms were made for roosting of the chicks. During 1997, the same pair made an extra platform at 10m distance from the nest and a second platform at 50m distance on the bund of a paddy field.

Table 4. Frequency (%) distribution of Pigmentation Index on Sarus Crane egg.

Location on the egg	Pigmentation Index 3	2	1	0
Broad end	92.3	38.7	9.09	14.28
Middle	0	48.4	33.33	28.57
Narrow end	7.7	12.9	57.58	57.14

n = 28

Egg

Color

The colour of the egg was white, chalky white with very light shade of cream, light blue or pinkish with pigment spots of varying sizes. The pigment colour ranged between dark brown to light red, with varying shades. The pigment spots were found all over the egg with a definite pattern of concentration. The frequency of pigmentation index (P.I.), P.I. 3 was highest (92.30%) at the broader end, P.I. 2 was maximum in the middle

Table 5. Diametrics of Sarus Crane eggs (1996 -1998).

Particulars	(n)	Length (cm)	Breadth (cm)	Volume (cm^3)	Weight* (g)	Fresh wt. (g)	(n)	ESI
Mean +	70	10.05	6.44	213.6	216.23	206.57	7	64.16
S. em		0.05	0.03	2.97	4.93	8.85		0.45
Range		8.87 to 10.9	5.72 to 7.06	155.68 to 273.27	164.0 to 286.0	164 to 239		54.20 to 73.56

* Egg weight irrespective of day after laying
E S I Egg Shape Index = Breadth / Length X 100
NB Fresh weight of only seven eggs were confirmed.

part (48.4%), while narrow end had either P.I. 1 or P.I. 0. It can be concluded that the highest P.I. was at the broader end and the concentration progressively decreased or even became nil at the narrower end (Table 4).

Shape

The egg shape was long oval or ovate (type 8) with slight variations within the clutch and between clutches. In a few cases, oblong, oval or elliptical (type 5) egg shapes were also observed (Campbell & Lack, 1985). The shape index varied from 54.20 to 73.56 (Table 5).

Shell weight

Three eggs failed to hatch (over due) and 12 due to unknown reasons were blown and evacuated. The mean shell weight was 5.2g. Romanoff and Romanoff (1963) reported an average shell weight of 11.9g for eggs from 10 different species of precocial birds.

Egg placement and inter-egg distance

In all the observations the broader end of one egg always lay beside the narrow end of the other egg. This juxtapositioning of the egg by the crane helped in management of space while incubation. A range of 15 to 20cm distance between the eggs was proportionate to the size of the incubating bird.

Diametrics

Diametrics of 70 eggs were recorded and are shown in Table 6. The mean value of egg diametrics did not show any significant annual variation. The measurement of length, width and weight showed that width was the most constant of all the parameters. This was related to the fact that eggs originate in an oviduct whose cross sectional area has a limited extensibility (Romanoff & Romanoff, 1963). Kuyt (1995) also found that egg width was the most constant measurement of a Whooping Crane's egg. The variations noted in egg weight or volume may be attributed to the date of observation after egg laying and also to its sequence within the clutch.

Egg diametrics with reference to sequence in clutch

Egg sequence was definitely known in seven clutches. The data of diametrics (Table 7) showed that in all parameters, the first egg was invariably larger than the second egg of the same clutch. A comparison by student's 't' test showed a significant difference in all the parameters except ESI. Compared to other parameters, S.Em of ESI for the second egg was always very high compared to the first egg. In one of the exceptional clutches in which egg sequence was definitely known, the second egg was certainly shorter in length, but had higher value of breadth (7.00cm and 7.06cm.), weight (282g and 286g), volume (272.39cm^3 and 273.37cm^3) and the ESI (64.22 and 65.67) of first and the

Table 6. Egg diametrics (n = 7) with reference to egg sequence in clutch.

Sr. No.	Length (cm)		Breadth (cm)		Weight (g)		Volume cm^3		ESI	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mean +	10.22	9.7	6.45	6.33	215.29	199.46	217.24	199.31	65.14	65.39
S. Em	0.08	0.18	0.09	0.3	7.29	7.8	5.84	8.71	0.85	1.48
(df 12)	3.2		2.21		3.89		2.97		-0.17	
Test	**		*		**		*		NS	

** Significant at P < 0.01 * Significant at P < 0.05

Table 7. Comparison of the egg diametrics measured by different workers...

Egg diametric	Blaauw (1897) (n = 51)	Baker (1928) (n = 100)	Walkinshaw (1973) (n = 10)	Walkinshaw* (1973) (n = 73)	This study(1996-1998) (n = 70)
Length (mm)					
Mean	101.5	104.4	101.1	101.35	100.5
Range	-	93.2 - 113.2	93.2-112.3	88.3-112.7	88.7 - 109.0
Width (mm)					
Mean	65	64.3	62.76	64.27	64.4
Range	-	53.82 -69.8	58.7 -65.6	58.7 - 70.1	57.2 - 70.6
Weight (g)					
Mean	-	-	212.56	-	216.23
Range	-	-	183.4- 247.6	-	164.0 - 286.0

* Including measurements from museum collection

second egg respectively. A slight increase in the breadth of the second egg had tremendously influenced the value of weight, volume and ESI. The results also indicated that usually there was significant reduction in the length of second egg but egg breadth did not get reduced significantly. Hence, it was possible to determine sequence of an egg within a clutch using egg diametric parameters.

Based on the above results, in the remaining clutches the larger egg was given the sequence number "one" and the shorter as "two". Comparison of the two eggs of 19 clutches revealed that in 11 clutches all the parameters of first egg was higher than the second. In eight clutches the breadth of the second egg was comparatively higher than the first egg; in seven clutches weight of the second egg was higher than the first egg; in three clutches volume of the second egg was higher than the first and in four clutches the ESI of the second was lower than the first egg. This comparison and the earlier established trend suggests that for detection of the egg sequence in a clutch, the parameter of egg length is the more reliable criterion.

Clutch size

Out of 70 nests recorded, definite information on clutch size was available from 69 nests. The clutch size was two in 68 nests and one in one nest. In nine nests, clutch size could not be determined. Out of such nine nests, there was no information about eggs in three nests. Three nests had one egg each at the time of examination but circumstantial information about the clutch size during preceeding period or following period could not be collected, however information revealed that there were two eggs in each and hence such cases were omitted for consideration of clutch size.

On 25th July 1997, one nest with an egg was recorded. However, it was destroyed before clutch completion. The pair renested and laid a clutch of two after 14 days. We never came across a clutch of three eggs, however we were informed by a farmer about a clutch size of three in a nest built in marsh. This information was received only after the hatching of the chick and hence could not be confirmed.

Discussion

Nest

Most of the cranes nest in wetlands, sometimes man-made (White, 1987). In our study area, the Sarus Cranes nested within man-made wetland, i.e. agricultural marshland. Almost 97.14 per cent nests were located within agricultural marshland, which highlights its importance. Amongst the other cranes, the Demoiselle Crane and the Sandhill Crane are also known to nest in agricultural fields (Kovshar, 1987; Winter, 1991). Within the agricultural marshland, equal number of nests were recorded in paddy cultivated area and non-cultivable agricultural marshland, however, selectivity index of paddy cultivated area was negative. Since survival of the nest within paddy cultivated area was very less, the nests which we could record were those which survived. Farmers even scared territorial pairs to avoid nesting in their fields. In this situation, non-cultivable land within agricultural marshland proved highly beneficial to the breeding cranes. Non-cultivable marshland is usually created by a poor drainage system, uneven land and seepage from the canal. Unless such safe microhabitats are maintained, the Sarus

Crane will find it difficult to survive in agricultural marshland. The Cranes have disappeared from highly modern agricultural landscape of Punjab and Haryana (Gole, 1989). Considering agricultural modernization, Gole opined that the Sarus Crane was numerous in the so called 'backward areas of the country'. However, this backwardness is important for the survival of Sarus Crane. Hence, non-cultivable marshland should be maintained within agricultural marshland for Sarus Crane conservation.

Walkinshaw (1973a) had measured dimension of nine nests of Sarus Crane. Probably all were taken from natural marshland. His values of length and width at water level averaged 150.7 (94-277) x 167.7 (119-309) cm across and the nests were narrow at the top. The average water depth adjacent to nest was 33.4cm. It is clear from the data that the nest diametrics and water depth around the nest was the function of microhabitat in which the nest was built. The water depth in the agricultural marshland was certainly higher than the one reported for natural marshland by Walkinshaw (1973a).

The present study highlights the importance of microhabitats in determining nest diametrics. The most significant feature of the concerned microhabitat showed its influence on the particular parameters of the nest diametrics. The length of the nest did not vary according to the microhabitat as there was no physical feature of the microhabitat which would restrict the length of the nest. The variation of 50cm in length amongst different microhabitat could be due to the stage at which the measurements were recorded. It is possible that the nest diametric measured above water level will show greater value, if measured after the water recedes from its maximum height.

Nest width varied significantly and was influenced by the bund width of the agricultural land or the width of the seepage canal or nesting on the elevated land in which width and length were equal and probably minimum than other microhabitats except in the paddy fields. The width was maximum in marshy agricultural wasteland and was almost equal to its length. The reason may be attributed to the fluctuation in water depth. Very often we observed the cranes adding nesting material to the nest in response to sudden increase in water level in the surrounding area. This certainly elevated the nest platform above the water surface and thus prevented the eggs from drowning. Such nests in the marshy area showed greater value in nest dimensions. Walkinshaw (1973b) also observed variations in the dimensions of Sandhill Crane's nests recorded in different microhabitat. However, he attributed these difference to the type of vegetation used for nesting.

Nest height above water surface did not vary significantly in different microhabitat, suggesting that the cranes maintained a constant distance between eggs and water surface. Nest height from the ground was influenced by bund height and by water depth in microhabitat. The nest height was highest as the water level was fluctuating due to regular flow in the canal. The nest height was lowest in paddy fields, as the water depth was maintained almost constant. In paddy fields water level was never more than the bund height. Hence the nest material requirement in these microhabitat was minimum.

Water depth near the nest varied significantly and the minimum water depth was 25cm, however depending upon the microhabitat, the Sarus Crane nested in the microhabitat having as much as 65cm of water depth. Walkinshaw (1973a) recorded about one meter water depth around the Sarus nest at Keoladeo National Park. In several other cranes, particularly the Common Crane, minimum water depth around the nest was ca. 50cm. (Neumann, 1987). The significance of specific water depth around the nest was chiefly to prevent the approach of ground predators to the nest. Certain height of the nest above ground helped the incubating Sarus Crane in maintaining a continuous vigil against predators from a distance and from human disturbances particularly during agricultural operations. In case of Sandhill Cranes, they preferred to have cover with a structure and density that allowed them a clear view while incubating and free movement when walking to and from the nest (Walkinshaw, 1950; Bennett, 1978).

The cranes collected nest material from the immediate vicinity of the nest site (Walkinshaw, 1973a; Ramchandran & Vijayan, 1994). Earlier studies on nest material was done on the nests located within protected/natural marshland and only a few aquatic plants were recorded. In the present study, we recorded at least 23 plants species as nest material within agricultural marshland. Two weed plants were used with high frequency.

All the nests built in non agricultural land, had *Typha angustata* as the major nesting material. *Typha* was the most abundant material in the concerned microhabitat, in addition, it possessed large biomass and hence was utilised for nest building. While nesting within the paddy crop, the cranes had no other option but to use paddy plants as nesting material. This was because of the removal of the weeds. While nesting on the bund of the paddy fields, the cranes often utilised the heap of removed weeds. The nest built on the bund, before transplantation of paddy seedlings, also showed very high diversity of aquatic plants as nesting material. The Sandhill Crane also incorporated different plant material in its nest while nesting in different microhabitats (Walkinshaw, 1973b). However, the Blue Crane, Demoiselle Crane, Mississippi Sandhill Crane and Cuban Sandhill Crane characteristically nest virtually in a dry barren situation (Walkinshaw, 1953, 1963; Xueming & Junchang, 1991; Layne, 1982; Toland, 1991; Valentine, 1981).

The Sarus Crane was opportunistic in the collection of nest material. Any green vegetation within the marshy area was picked up as nesting material. This was the major reason behind the utilisation of 23 plant species as nesting material in non-cultivable marshland. We have not listed the plant species occurring in very small number, however we have records of the occurrence of *Nymphoides* spp., *Lemnia*, *Azolla*, *Wolfia* and floating algae. Moreover, dried plant material was also used as nesting material. Addition of decaying plant debris to the nest platform was also recorded. The tendency to utilise decaying debris for nest building by the Sarus Crane was also observed by Walkinshaw (1973a).

In the cranes, both the sexes share the duty of nest building activity (Walkinshaw, 1973a; Johnsguard, 1983). The responsibility of nest building was shared by both the sexes and hence the nest platform was prepared within a short period of 2-3 days. Once sufficient quantity of nest material had been collected, the female stopped collecting materials from a distance but kept arranging the floating nest materials being supplied by the male to the nest platform. This division of labour might help the female in conserving her energy prior to egg laying. Even during incubation there was a clearcut division of labour in collection and arrangement of nest materials. As the female spent more time in incubation compared to the male, this division of labour was justified. Even the White-naped Crane (Liying & Jie, 1991) and Sandhill Crane (Walkinshaw, 1973b) continue to add nest material during incubation.

All the breeding cranes did not make equal effort in nest building activity, as some of the pairs were opportunistic in using the readily available cut heap of plant material. This suggested that for egg laying, an elaborate process of nest building was not required, probably because then cranes paired for long periods. However prolonged nest building activity is a prerequisite before egg laying for many other birds which pair for a single season (Farner *et al.*, 1971). Acceptance of piled up heap of weeds as a nest, suggested that the Sarus Crane did not make any additional effort to pull fresh plant material to build its nest. In some of the nests built on the paddy field bunds, we had confirmed that there was very little damage to the paddy crop around the nest site. This clearly indicated that to minimise the damage to the paddy crop, the farmer should retain heaps of weeds on the bund.

Correlation between water depth and nest height revealed that the nest height was the function of water depth around the nest. In non-cultivable marshy wetland, a strong positive correlation was established between water depth and total nest height above the ground ($r = 0.78$, $d.f. = 28$, $P < 0.05$). The reliability of the regression equation worked out was 62 per cent. In some microhabitat like *khet-talavadi*, the cranes nested on slightly elevated land. Such nests showed poor correlation of the water depth requirement against nest height. Such nest characteristics reduced the dependency of the correlation established. As it can be seen from the regression equation ($Y = 32 + 0.814\ X$), minimum nest height was 32cm. For Whooping Crane, Kyut (1995) had established a positive correlation between water depth around the nest and corresponding nest height from ground

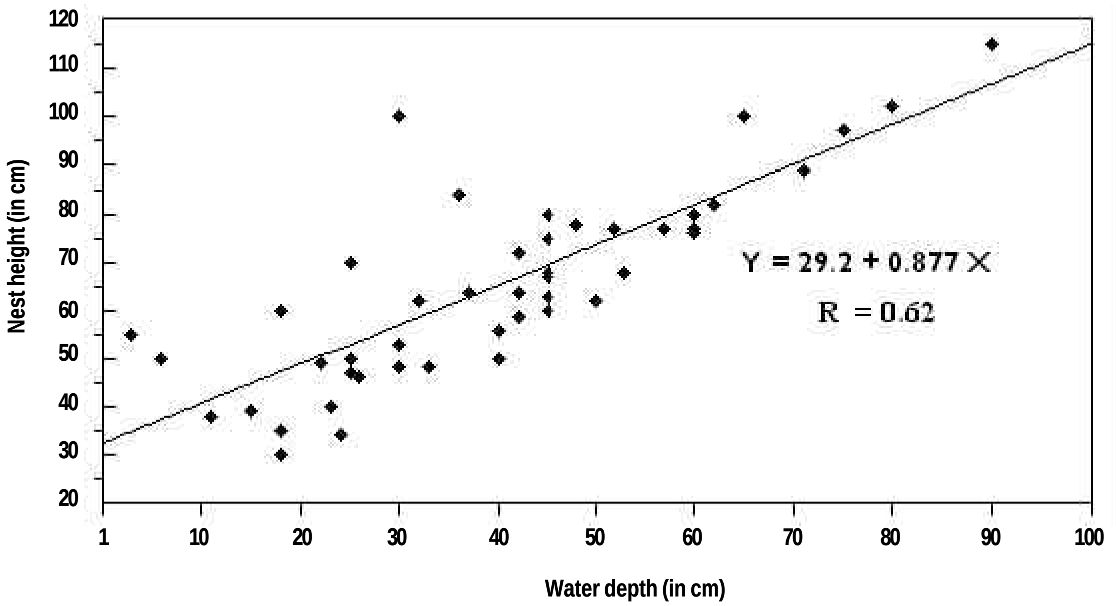

Figure 2. Corelation between mean water depth and nest height.

over several years.

Nest site fidelity is a common tendency in Sarus Crane (Walkinshaw, 1973a; Gole, 1987) and several other crane species (Walkinshaw, 1973a, 1973b, 1976, 1989; Kuyt, 1995). The total period of the nest site fidelity shown by the Cranes for a particular site indicated its suitability particularly with reference to disturbance (Walkinshaw, 1949; Bennett & Bennett, 1990). The disturbance on the nest site could be physical (flooding) or biological (predation etc.). During the present study, the case of long term fidelity was recorded from the non-cultivable marshland. Naturally, the safety of the nest was comparatively higher than the cultivable marshland (paddy). However, we came across a few nests with a long term nest site fidelity within the paddy fields also. Such cases were the indication of a farmer's tolerance towards crop damage due to nesting cranes in his fields, and the reason may be attributed to cultural heritage.

The preparation of extra nest platform after hatching of the chicks were not reported earlier. However, the White-naped Crane is known to build fake nests besides the original one at a distance of 50 to 100m (Liying & Jie, 1991; Chunyuan *et al*., 1991). The extra platform was only found in the microhabitat which remained inundated for a long time. As extra nest platforms were always found very close to the original nest site, it suggested that these platforms were basically meant for roosting and the family did not leave the nesting site for more than one month. Due to such activity the Sarus Crane indirectly caused additional damage to the paddy crop to some extent. Since such a behaviour was observed only in 10 per cent of the total nests observed, it was surmised as uncommon behaviour.

Egg

The mean values of egg diametric were closer to the value given by earlier workers. Earlier workers collected data from the larger area of its distribution whereas ours was from a specific study site and hence the range of values was less (Table 7).

Mean fresh weight of Sarus Crane egg was 206.57g and the incubation period was 31-33 days. The egg constituted 2.8 per cent of the average adult female cranes body weight (7.4kg, Ellis *et al*., 1996). The observation agrees with the earlier established fact that larger birds lay proportionately smaller eggs than small birds (Pettingill, 1971; O'Connor, 1985).

Borad (1998) had established that the first egg of a clutch was always larger in all the parameter except ESI compared to the second egg. The same result was further confirmed in the present study with a larger sample size.

The variation observed in egg diametrics within a clutch was very small compared to the variation noted between clutches. The inter-clutch variation in the egg may be an inherent character of the concerned female (O'Connor, 1985). The difference in the egg size between clutches could also be attributed to the age of the female (Romanoff & Romanoff, 1963).

All *Grus* sp. typically lay two eggs (Johnsgard, 1983). The normal clutch size of the Sarus Crane is two (Ali & Ripley, 1983). Blaauw (1897) reported that in over 100 sets of eggs, only two consisted of three, the remainder consisted of two eggs. Walkinshaw (1973a) had seen five complete sets of clutches, all having two eggs. However, he gave details of 132 sets of which egg number is given; there were four sets of one, 126 of two and two sets of three, average 1.985 eggs. Ramachandran and Vijayan (1994) found 18 per cent clutches having one egg and 82 per cent clutches having two eggs at Keoladeo National Park. Reduction in the clutch size over a few years at Keoladeo National Park was attributed to the degradation in the quality of habitat (Ramachandran & Vijayan, 1994). However, in our study we did not find any reduction in clutch size.

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