Further analysis revealed that the population of Greylag Goose *Anser anser* also fluctuated in BWLS over the years. In TB, the numbers of Bar-headed Goose, Brahminy Shelduck, Northern Pintail and Gadwall decreased significantly compared with figures of 1997 (Mookherjee *et al.* 1999). Red-crested Pochard *Rhodonessa rufina*, 903 birds in 1997, was altogether absent in TB in 2006. During 2006, members of Laridae were altogether absent from all the study sites. However, Brown-headed Gull *Larus brunnicephalus* was reported from NB in 1991 and SJ in 1992, and Black-headed Gull *L. ridibundus* were recorded from NB during 1991, 1994 and 1995 (Mookherjee *et al.* 1999).

From the present observations it can be concluded that all these sites are important wintering grounds for a number of waterbirds and wetland-associated species. However, additional observations at these sites at other times of the year, and over several years, are needed to provide a deeper insight into their value for waterbirds.

Abbreviations

R= Resident; RM=Resident migrant; M=Trans-Himalayan migrant; V=Vagrant.

BB=Bakreshwar Barrage; BWLS=Ballavpur Wildlife Sanctuary; NB=Nalban Bheri; SB=Saheb Badh; SJ=Santragachi Jheel; TB=Tilpara Barrage.

Acknowledgements

We are grateful to the chairman of West Bengal Biodiversity Board for necessary permission to carry out the fieldwork. Thanks are also due to Prakriti Samsad and Institute of Wetland Management and Ecological Studies (IWMED) for their help and cooperation. We also acknowledge the Forest Range Officer of Ballavpur Wildlife Sanctuary for giving necessary permission to undertake census inside the protected area. We also wish to thank the unknown referee for improving this paper.

References

Ali, S. 1996. *The Book of Indian Birds*. (12th Revised edition). New Delhi: Oxford University Press.

Anon. 1998. *Wetlands and Waterbirds of West Bengal*. Kolkata: Nature Environment & Wildlife Society.

Grimmett, R., Inskipp, C. and Inskipp. T. 1999. *Pocket Guide to the Birds of Indian Subcontinent*. New Delhi: Oxford University Press.

Manakadan, R. & Pittie, A. 2001. Standardized common and scientific names of the birds of the Indian subcontinent. *Buceros* 6 (1): 1-37.

Mazumdar, S., Ghosh, P. & Saha, G. K. 2005. Diversity and behaviour of waterfowl in Santragachi Jheel, West Bengal, India during winter season. *Indian Birds* 1 (3): 68-69.

Mookherjee, K., Chatterjee, S., Deuti, K. & Chaudhuri, C. 1999. *Mid-winter Waterfowl Census in southern West Bengal. 1990–1997.* Calcutta: Prakriti Samsad.

Pettingill Jr., O. S. 1956. *A Laboratory and Field Manual of* Ornithology. Minnesota: Burgess Publishing Company.

Sonobe, K. & Usui, S. (eds.) 1993. *A field guide to the waterbirds of Asia.* Tokyo: Wild Bird Society of Japan.

Observations on breeding biology of three stork species in Bhitarkanika mangroves, India

Gopi. G. V. & Bivash Pandav

Gopi, G. V. & Pandav, B. 2007. Observations on breeding biology of three stork species in Bhitarkanika mangroves, India. *Indian Birds* 3 (2): 45–50.

Gopi G. V., G.B. Pant Institute of Himalayan Environment & Development, North-east Unit, Itanagar 791113, Arunachal Pradesh, India. Email: *gopigv@gmail.com*

Bivash Pandav, WWF-International, C/o WWF-Nepal Programme, P. O. Box # 7660, Kathmandu, Nepal. Email: *pandavb@wii.gov.in*

Mss received on: 16.i.2007.

We present some breeding notes for Lesser Adjutant-Stork *Leptoptilos javanicus*, Asian Openbill-Stork *Anastomus oscitans* and Painted Storks *Mycteria leucocephala* in the Bhitarkanika mangroves from August 2004 to December 2006. Observations on colony size, nest biology, hatching success, and productivity are reported. All the stork species nested amidst thick mangrove vegetation. Productivity was higher for Lesser Adjutant-Storks, than for the other two species. We also discuss certain conservation issues related to these storks in Bhitarkanika.

Introduction

Nine of the 19 species of storks found globally, occur in India (Ali & Ripley 1987, del Hoyo *et al.* 1994). Of these, Lesser Adjutant-Stork *Leptoptilos javanicus*, Asian Openbill-Stork *Anastomus oscitans*, Painted Stork *Mycteria leucocephala* and Black-necked Stork *Ephippiorhynchus asiaticus* inhabit Bhitarkanika mangroves (Pandav 1997). These species nest colonially, displaying spatio-temporal clumping of nests, with colonies sometimes comprising thousands of nests and holding multiple species of birds including other storks, herons and egrets (Ali & Ripley 1987, Burger 1981, Krebs 1987). A few long term and detailed studies on these aspects include the work of Singh *et al.* (1986) on the biology of Cattle Egret in Punjab and, the observations of Kahl (1970, 1971) on the breeding biology of

Painted Stork and Asian Openbill-Stork in Bharatpur. Desai *et al.* (1978) and Urfi (1993) studied the reproductive patterns of Painted Stork in Delhi Zoo. Mukhopadhyay (1980) described the breeding biology of Asian Openbill-Stork in southern West Bengal. Parasharya (1990) studied in detail the breeding biology of some Ciconiiformes in selected coastal areas of Gujarat. Sivasubramanian (1992) reported on the breeding biology of the colonial nesting birds of Keoladeo National Park (Rajasthan). Subramanya (1996) compiled information on the heronries across India.

BirdLife International (2001) classifies three species of storks as 'endangered' (Oriental White-Stork *Ciconia boyciana*, Storm's Stork *C. stormi*, and Greater Adjutant-Stork *L. dubius*) and two as 'vulnerable' (Lesser Adjutant-Stork and Milky Stork *M. cinerea*). The Painted Stork and the Black-necked Stork are listed as 'near-threatened'. Many other species are suffering regional declines in the face of ever-increasing pressure for agricultural land and housing development. Bhitarkanika harbours two near-threatened storks and one vulnerable stork species. Since, there exists very little information on the breeding status of the storks in Bhitarkanika; this study collected information to establish base line data on the breeding biology of the storks.

Study area

Bhitarkanika (20°30'–20°48' N 86°45'–87°03'), in Orissa (India), is the second largest mangrove ecosystem of India. It flourishes in the deltaic region formed by the rich alluvial deposits of the Brahmani, Baitarani and Dhamra Rivers (Fig. 1).

We have recorded a total of 261 bird species, belonging to 49 families, from here. The annual rainfall ranges from 920–3,000mm. Bhitarkanika contains one of the richest and most diversified mangrove floras in the country. The region comes under the tropical monsoon climate with three pronounced seasons: winter (October–January), summer (February–May) and rains (June–October). The maximum temperature is recorded in April–May and the minimum during winter in January. The relative humidity ranges from 70%–84% throughout the year. Wind speed from March to June is over 20kmph, and the predominant wind direction is from the south and south-west.

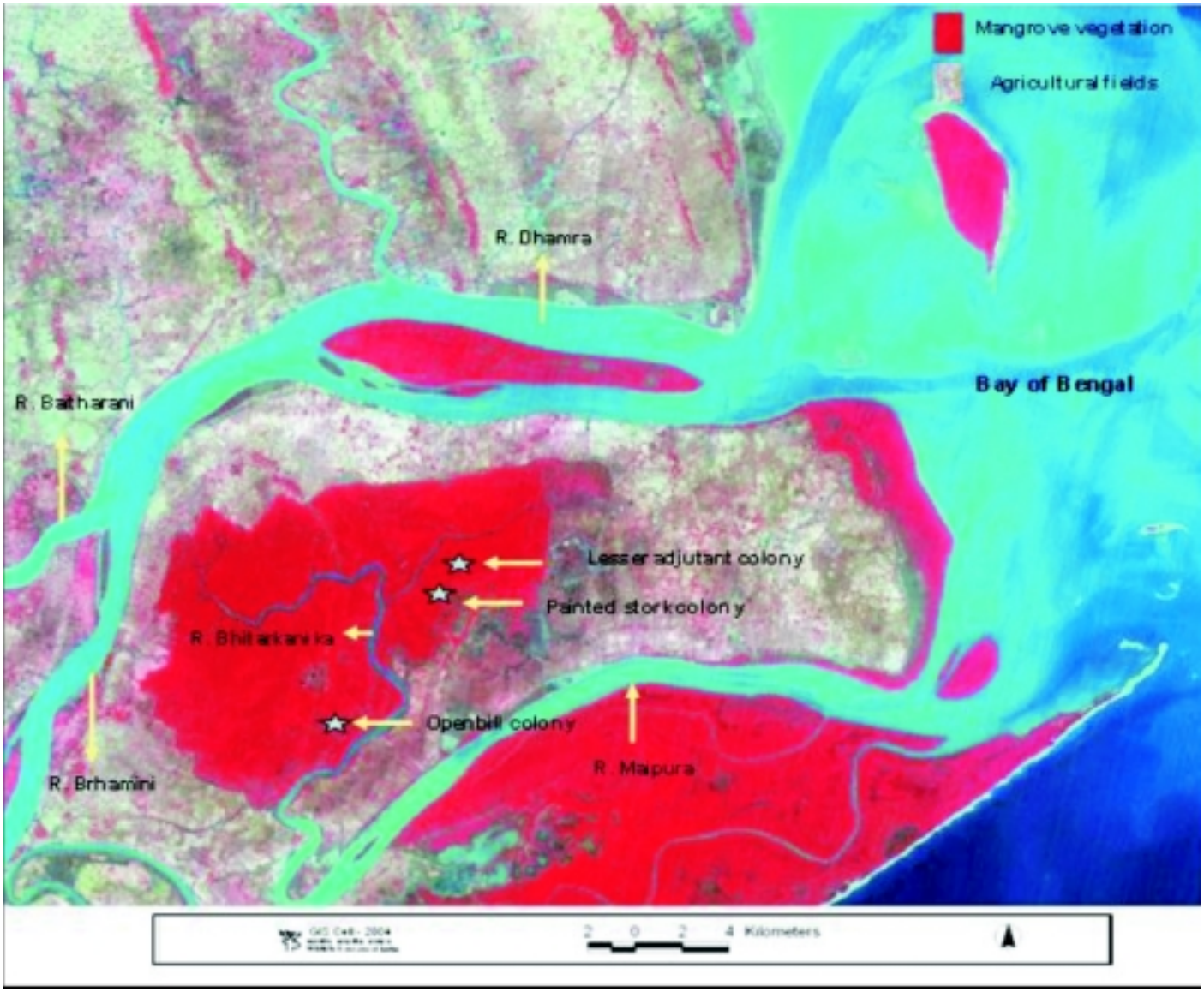


Fig. 1. Map of Bhitarkanika Wildlife Sanctuary

Methods

Fieldwork was conducted in Bhitarkanika mangroves from August 2004 to December 2006. All the three storks do not nest together—but at three different sites at Bhitarkanika. Asian Openbill-Storks nest in a heronry with ten other nesting waterbirds, while Painted and Lesser Adjutant- storks make their own colonies. The Asian Openbill-Stork colony was visible due to their large numbers, but the nests of the other two species were not easily visible. To locate the latter, secondary information was collected on presence and activity of the storks from fishermen and other villagers—who collect honey in the mangroves. The areas were subsequently searched on foot, at regular intervals, to determine if nests of the focal species occurred where indicated. On locating a colony, similar monitoring protocols as detailed above were carried out.

A census of Asian Openbill-Stork nests was carried out in the last week of August (2004, 2005, 2006), just after most of the eggs had hatched. All the trees in the heronry, with nests, were counted and marked numerically with paint. Parameters like, tree species, tree height, girth at breast height (GBH), bird species nesting on the tree, number of nests, and nest height were recorded. Nest and tree heights were visually estimated to the nearest foot (0.30m). GBH was measured with an inch tape. Avian species guarding nests were used as indicators to identify nests and during the absence of adult birds we relied on nest design and materials used, to identify the species.

With the onset, in early June 2004, of the strongly seasonal south-west monsoon, the Asian Openbill-Stork heronry was girded into 17 50x50m blocks. Five trees were randomly selected from each block and marked with red paint and white cloth for easy identification. These trees were monitored on alternate days and, variables like tree species, nest height, nest initiation date (NID; date on which nest material was first placed in the marked tree by a nesting pair. Different nests had different NIDs), clutch initiation date (date of first egg being laid), egg laying dates, egg measurements, clutch size (clutch size=total number of eggs in each nest). Egg morphometry was studied as follows: Length (L) and breadth (B) of each egg were measured to the nearest 0.1mm using calipers. Egg volume was calculated using the formula $V=0.51xLxB^2$ (Hoyt 1979). Total clutch volume was taken as the sum of volumes of all the eggs in a clutch.

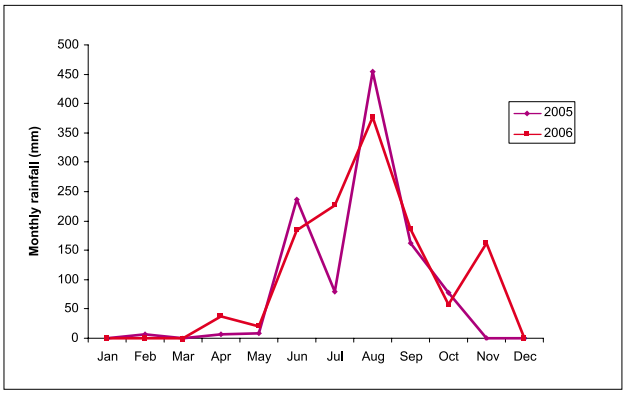


Fig. 2a. Monthly rainfall in Bhitarkanika mangroves

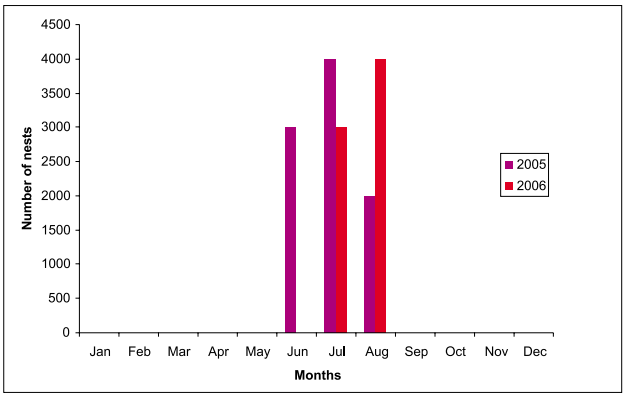


Fig. 2b. Months of egg laying by Asian Openbill-Storks

Nests that failed before full clutch size was reached were excluded from the analysis. Nest measurements at different stages (i.e., laying, hatching and fledgling) and nest materials used were recorded.

We used focal-animal sampling (Altmann 1974) for behavioral observations. One of us (GGV) carried out all the behavioural observations. One bird of a pair was selected and observed for a maximum of four hours per sample. We discarded all observations of less than one minute. We recorded durations of copulation and bouts of incubation and incubation interval time.

Once nest building started, each nest was discreetly marked with a small aluminum tag bearing a unique alphanumeric code for identification of individual nests. Nests were checked on alternate days and their status noted by two observers simultaneously working in different parts of the colony. Different routes were used to approach and leave the nests. All observations were restricted to the cooler parts of the day (06:30–08:00hrs) to avoid over-heating of the eggs. The entire colony was not disturbed for more than an hour per monitoring. Birds left the nest when observers approached within 2–5m. However, they returned no sooner the observer moved away. Our checks lasted till the last chick had fledged from the colony. We considered young as successfully fledged, when they were old enough to fly across open space to trees away from their nests. For studying nest morphometry we measured their circumference and diameter. Even when one egg hatched, we treated it as a hatching success Productivity was calculated as number of chicks that survived up to the fledgling stage and dispersed from the nest.

Nesting

Asian Openbill-Storks started to arrive to the heronry by mid June (2004, 2005, 2006), laying eggs from early July (2004, 2005, 2006). However, Painted and Lesser Adjutant- Storks arrive in late September (2005, 2006) and start laying eggs by early October (2005, 2006). Asian Openbill-Storks dominated (>60%) the breeding birds in the colony (Gopi *et al.* 2005). Approximately 14,000 Asian Openbill-Storks bred in the mixed species heronry during our study (Table 1). Painted and Lesser Adjutant- Storks, which form their own colonies, breed in very low numbers (Table 2). All these storks prefer thick mangrove vegetation for nesting. Asian Openbill-Storks prefer *Excoecaria agallocha* trees, while Painted Storks,

Table 1. Enumerated number of nests in Bhitarkanika

	Openbill stork	Painted stork	Lesser Adjutant stork
2005	7568	13	0
2006	8493	8	4

Heritiera fomes and Lesser Adjutant-Storks, *Xylocarpus mekongensis.*

Asian Openbill-Stork

The Asian Openbill-Stork is the smallest and commonest of the storks found in India. It is sighted all over Bhitarkanika, throughout the year, and has an approximate population of 30,000. Breeding commences with the onset of the south-west monsoon, in mid-June and lasts till January (2004, 2005, 2006). They were the predominant (66%) nesters in the heronry (20º42'09.8"N 86º52'20.8"E) that we studied. They build a platform nest and like other stork species, both male and female share nest building and incubation. Asian Openbill-Stork preferred a variety of nesting material unlike the other two species studied. The nest material included dry twigs of *Hibiscus tiliaceus, H. fomes, Sonneratia apetala, and Salvadora persica.* Green leaves and twigs of *Excoecaria agallocha* were widely used to line nests (Fig. 3).

The copulation-duration of the Asian Openbill-Stork was 7.45 sec (±1.25 sec; n=75). The Asian Openbill-Stork had the higher mean clutch size of 4.45 (±1.36) and 4.36 (±2.90) in 2005 and 2006 respectively, in comparison to Painted and Lesser Adjutant- Storks (Table 3). Egg morphometry studies revealed that Asian Openbill-Storks produce smaller eggs, both in terms of length, and mass, in comparison to the other storks (Table 4). Chicks hatched after an incubation period of approximately 25–26 days (Table 5).

Lesser Adjutant-Stork

Juveniles were sighted in March 2003 by Pandav (1997). However no breeding colony was located in Bhitarkanika till 2005. In early September 2006, a small breeding colony was located near Balijori creek (20º43'25"N 86º51'46"E). Birds were making nest-platforms using twigs of *Avicennia* and *Dalbergia* spp. Lesser Adjutant-Storks are often sighted in the open meadows, adjacent to mangrove forests in Bhitarkanika, at Mahisamada plantation, Bhitarkanika Patia, Raipatia, Baisigharia, Musadiha and Jagannathprasad dia. These areas where they were often sighted were. Approximate population in Bhitarkanika is 20.

Copulation-duration of Lesser Adjutant-Storks was 18.34 sec (±8.45 sec; n=5). Their nests were larger in comparison with the other storks (Table 2), which may be due to their larger body size. Four nests were located during the study and all four had a clutch of three eggs each. Egg morphometry showed a similar trend to that of Painted Storks (Table 4). Incubation period of Lesser Adjutant-Storks was 29.56 (±1.13) days (Table 5).

Table 2. Nest measurements of AO, PS, LAS

	AO (n=45)	PS (n =8)	LAS (n=4)
2005	169.00 ± 16.66	200.83± 13.0	NA
2006	166.1± 16.3	196.25±14.52	210±15.62

Table 3. Mean clutch size

	AO (n=45)	PS (n =8)	LAS (n=4)
2005	4.45± 1.36	3.8 ± 1.09	NA
2006	4.36 ± 2.90	3.75 ± 1.53	3.0 ± 0.00

Painted Stork

Seen throughout the year at Bhitarkanika Patia, banks of Maipura River, Raipatia, Satabhaya, and Mahisamada plantation. Breeds in a small colony (20º43'10.8"N 86º51'52.6"E) in Bhitarkanika block near Gunakar ghat from September–January on platform nests. 14 and eight active nests were counted during the 2005 and 2006 seasons respectively. The approximate population is 100.

Copulation-duration of the Painted Stork was 9.56 sec (±1.75 sec (n=15). There was no significant difference in clutch size between the years; however the Painted Stork had a mean clutch size of <4 eggs (Table 3). Egg morphometry revealed that Painted Stork produce eggs similar, both in terms of length and mass, to those of Lesser Adjutant-Storks (Table 4). Chicks hatched after an incubation period of approximately 29.56 days (±1.13) and 32.19 days (±1.13) respectively for 2005 and 2006 (Table 5).

Breeding success and productivity

Asian Openbill-Stork had the lowest hatching success but higher productivity in comparison to Painted and Lesser Adjutant- Stork. The reason could be either a larger clutch size or higher predation during egg laying stage, compared to the chick rearing stage, when a parent is always in the nest. Also, higher productivity would be due to social benefits of clustering (by increasing the fitness of the birds) which is one among the strong hypothesis that supports bird colonialism. Painted and Lesser Adjutant- Stork had a higher hatching success and lower productivity, due perhaps to higher predation pressure on chicks as compared to the eggs. Lesser Adjutant-Stork had a higher hatching, fledgling success and productivity than Painted Storks.

Discussion

Ali & Ripley (1987) state that the breeding season of storks is highly dependent on the monsoon and related water conditions, which trigger the abundance of food. This study also shows a strong relation between the monsoon and the nesting activity of storks (Fig. 2).

The breeding season of the Lesser Adjutant-Stork stretches from July to January (Grimmett *et al.* 1998). According to Ali & Ripley (1987), the Lesser Adjutant-Stork, apart from Assam, which is its stronghold, breeds in Sri Lanka, Kerala, parts of the Malabar Coast, Tamil Nadu and Bangladesh. Jha (1998) counted 14 nests of Lesser Adjutant-Stork in Kahala village (Malda district, West Bengal), though he did not state the time of year. Pandav (1997) reported it's breeding in the Bhitarkanika mangroves (Orissa).

The copulation duration of Greater Adjutant-Stork was 25.56 sec (±10.38 sec) (Singha *et al.* 2003), 10 sec in Painted

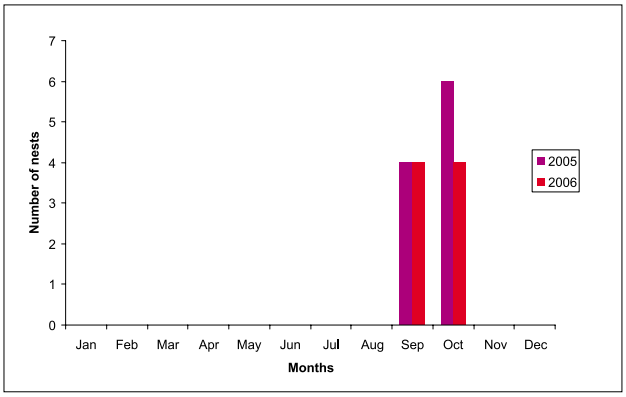


Fig. 2c. Months of egg laying by Painted Storks

Stork (Desai *et al.* 1978), 8.77 sec (±1.15 sec) in Maguari Stork *C. maguari* (Thomas 1986), 24 sec in Black-necked Stork *E. asiaticus* and 15 sec in Jabiru Stork *Jabiru mycteria* (Kahl 1973). In the present study, the Painted Stork's copulation-duration of 9.56 sec (±1.75 sec) differed slightly from the 10 sec record of Desai *et al.* (1978). Asynchronous hatching was observed in all the focal species. Lack (1968), states that in Ciconiiformes, successive eggs in a clutch are laid two or more days apart, that incubation starts with the first egg, and that the young hatch one or more days apart.

According to Lack (1968), the incubation period in Ciconiidae varies between 30–33 days. Asian Openbill-Stork had a minimal incubation period of 26 (±2.84). Incubation period for Painted Storks was similar to that recorded by Desai *et al.* (1978) in Gujarat. Lesser Adjutant-Stork had an incubation period of 28.55 (±8.86) days. We could not determine the reasons for the shorter incubation duration of storks in Bhitarkanika, when compared with that given by Lack (1968). Incubation periods for other storks are: Greater Adjutant-Stork 30 and 35 days reported by Saikia & Bhattacharjee (1996b) and Singha *et al.* (2003) respectively; American Wood-Stork *M. americana* 32 days (Heinzman & Heinzman 1965); White Stork *C. ciconia* 32 days (Schuz 1972); Maguari Stork 29–32 days (Thomas 1984, 1986); Painted Stork 32 days (Desai *et al.* 1978); White-necked Stork *C. episcopus* 30–31 days (Scott 1975); Abdim's Stork *C. abdimii* 28–30 days and, 29–31 days for Marabou Stork *L. crumeniferus* (Brown *et al.* 1982; Kahl 1972; Pomeroy 1978a). Mean clutch size of 3.8 (±1.09) eggs per nest, for Painted Storks, was higher in Bhitarkanika vis-à-vis 2.49 reported by Desai *et al.* (1978).

Conservation

The Asian Openbill-Stork feeds almost exclusively on *Pila globosa* mollusks, which comprise 98% of its diet (Gopi *et al.* 2006), obtained from the agricultural fields surrounding the Bhitarkanika Wildlife Sanctuary. Rice paddies are increasingly being converted into aquaculture farms in around the Bhitarkanika. 674 aquaculture farms, covering 321ha, were located along the periphery of the park alone. This illegal conversion of coastal wetlands will result in loss of foraging grounds for Asian Openbill-Storks. In future it may affect their breeding behavior and may be detrimental to their long-term survival.

Table 4. Egg morphometry of AO, PS, LAS

Species	N	Mean egg length (mm)	Mean egg width (mm)	Mean egg mass (cm3)
AO	84	42.06± 8.48	26.96± 5.38	168.4 ± 3.92
PS	15	56.22± 2.17	35.66± 5.82	172 ± 4.44
LAS	12	56.66± 2.31	36.66± 1.83	174± 1.90

Presently, the forest department conducts an annual census at the Asian Openbill-Stork heronry. A similar exercise should be initiated for the remoter Painted and Lesser Adjutant- Stork colonies. The dependence of these species on restricted nesting sites makes the preservation and scientific management of these sites critical for conservation.

Acknowledgements

Observations made during this study were carried out while undertaking fieldwork in the project "Ecological reconnaissance of colonial nesting waterbirds at Bhitarkanika mangroves, Orissa"—of the Wildlife Institute of India (WII). We are grateful to the Director, Bhitarkanika Wildlife Sanctuary, for infrastructure and facilities. We are deeply thankful to Mr Bijoy kumar Das, field assistant, for his extensive help, to the staff of the Orissa Forest Department who took care of our logistics and was very supportive during the field days. In, WII we would like to thank Rajah Jayapal and Ashish David for their comments and suggestions.

References

Ali, S. & Ripley, S. D. 1987. *Compact handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka.* 2nd ed. Delhi: Oxford University Press.

Altmann, J. 1974. Observational study of behavior: Sampling methods. *Behaviour* 49: 227-267.

BirdLife International. 2001. *Threatened Birds of Asia: The BirdLife International Red Data Book. Part A.* Collar, N. J., Andreev, A. V., Chan, S., Crosby, M. J., Subramanya, S. & Tobias, J. A. (eds.). Cambridge, UK: BirdLife International.

BirdLife International. 2001. *Threatened birds of Asia: The BirdLife International Red Data Book. Part B.* Collar, N. J., Andreev, A. V., Chan, S., Crosby, M. J., Subramanya, S. & Tobias, J. A. (eds.). Cambridge, UK: BirdLife International.

Brown, L. H., Urban, E. K. & Newman K. 1982. *Birds of Africa.* Vol. 1. London: Academic Press.

Burger, J. 1981. A model for evolution of mixed species colonies of Ciconiiformes. *Quarterly Review of Biology* 56: 143–167.

del Hoyo, J., Elliott, A. & Sargatal, J. (eds.) 1994. *Handbook of the birds of the world. Volume 2. New World Vultures to Guineafowl.* Barcelona: Lynx Edicions.

Desai, J. H., Menon, G. K. & Shah, R. V. 1978. Studies on the reproductive pattern of the Painted Stork, *Ibis leucocephalus* (Pennant). *Pavo* 15 (1&2): 1–32.

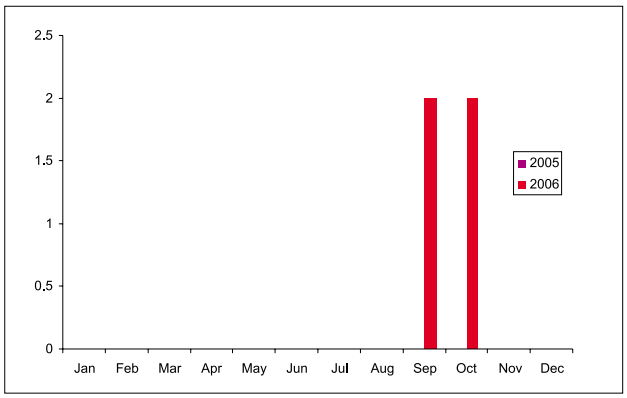


Fig. 2d. Months of egg laying by Lesser Adjutant-Storks.

Table 5. Incubation period of focal species

Species	Year	Total Number of nests	Nests monitored	% Hatching success	% Fledgling success	Productivity (Young raised/nest)
AO	2005	7568	45	45.74 ± 21.43	42.22 ± 40.12	2.4
	2006	8493	45	45.24 ± 38.64	41.14 ± 21.43	2.2
PS	2005	13	8	48.00 ± 37.52		0.6
	2006	8	8	50.22 ± 37.91	46.66 ± 33.54	0.5
LAS	2005	NA	NA	NA	NA	NA
	2006	4	4	57.74 ± 36.62	41.66 ± 37.52	0.8

Gopi, G. V., Pandav, B. & Kar, S. K. 2005. Colonial nesting of waterbirds in Bhitarkanika mangroves, Orissa, India. *Progress report No. 1.* Dehra Dun: Wildlife Institute of India.

Gopi, G. V., Pandav, B. & Kar, S. K. 2006. Colonial nesting of waterbirds in Bhitarkanika mangroves, Orissa, India. *Progress report No. 2.* Dehra Dun. Wildlife Institute of India.

Grimmett, R., Inskipp, C. & Inskipp, T. 1998. *Birds of the Indian Subcontinent.* London: Christopher Helm, A & C Black.

Heinzman, G. & Heinzman, D. 1965. Nesting of the wood stork. *Natural History* 74: 30–35.

Hoyt, D. F. 1979. Practical methods of estimating volume and fresh weight of bird eggs. *Auk* 96: 73–77.

Jha, S. 1998. A note on the breeding distribution of Lesser Adjutant *Leptoptilos javanicus*. *Newsletter for Birdwatchers* 38 (4): 71.

Kahl, M. P. 1971. Observations on the breeding of Storks in India and Ceylon. *J. Bombay Nat. Hist. Soc.* 67 (3): 453–461 (1970).

Kahl, M. P. 1971. Social behavior and taxonomic relationships of storks. *Living Bird* 10: 151–170.

Kahl, M. P. 1972. Comparative ethology of the Ciconiidae. Part 2. The Adjutant Storks, *Leptoptilos dubius* (Gmelin) and *L. javanicus* (Horsfield). *Ardea* 60 (1-2): 97–111.

Krebs, J. R. & Davies, N. B. 1987. *An introduction to behavioural ecology.* Oxford: Blackwell.

Lack. D. 1968. *Ecological adaptations for breeding in birds.* London: Methuen & Co. Ltd.

Luthin, C. S. 1987. Status of and conservation priorities for the world's stork species. *Colonial Waterbirds* 10 (2): 181–202.

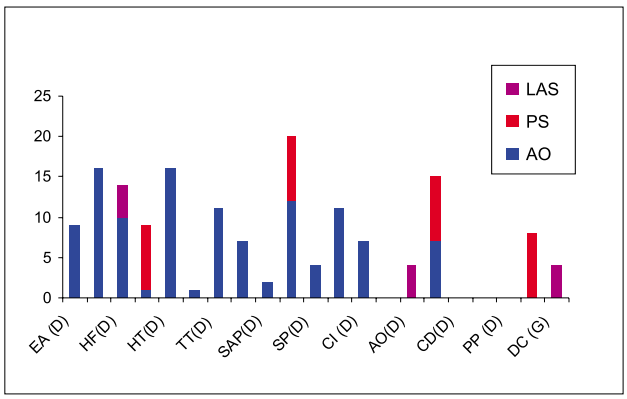
Maheshwaran, G. 1998. Ecology and behaviour of Black necked stork (*Ephippiorhynchus asiaticus* Latham, 1790) in Dudwa National Park, Uttar Pradesh, Unpublished PhD thesis, Centre for Wildlife and Ornithology, Aligarh Muslim University, Aligarh.

Pandav, B. 1997. Birds of Bhitarkanika mangroves, eastern India. *Forktail* 12: 7–17.

Parasharya, B. M & Naik, R. M. 1990. Ciconiiform birds breeding in Bhavnagar City, Gujarat. A study of their nesting and plea for conservation. Pp. 429–445. *In*: Daniel, J. C. & Serrao, J. S. (*eds*): *Conservation in Developing countries: Problems and Prospects.* Bombay: Oxford University Press.

Pomeroy, D. E. 1978. The biology of Marabou storks in Uganda II. Breeding biology and general review. *Ardea* 66: 1–23.

Rahmani, A. R. 1989. Status of the Black-necked Stork *Ephippiorhynchus asiaticus* in the Indian subcontinent. *Forktail* 5: 99–110.



* EA=*Excoecaria agallocha*, HF=*Heritiera fomes*, HT=*Hibiscus tiliaceus*, TT=*Tamarix troupii*, SAP=*Salvadora persica*, SP=*Salacia prinoides*, AO=*Avicennia officinalis*, CD=*Ceriops decandra*, DC=*Derris scandens* ('D' denotes dry twigs / leaves and 'G', green twigs / leaves)

Fig. 2. Nest material preference by AO, PS and LAS:

Table 6. Breeding success and productivity

	AO (n=45)	PS (n =8)	LAS (n=4)
2005	25.70 ± 4.90	29.56 ± 1.13	NA
2006	26 ± 2.84	32.19 ± 1.13	28.55 ± 8.86

Saikia, P. & Bhattacharjee, P. C. 1996. Studies on some aspects of the breeding biology of greater adjutant stork, *Leptoptilos dubius* from the Brahmaputra valley, Assam. *Tropical zoology* 1(1): 57-64.

Schulz, E. 1972. Other stork species. In: *Grzimek's Animal Life Encyclopedia* (ed. Grizmek, H. C). Van Nostrand Reinhold Co.

Scott, A. F. 1975. Observations on the breeding of the Woolly-necked Stork. *Ostrich* 46 (3&4): 201–207.

Singh, N. & Sodhi, N. S. 1986. Heronries and the breeding population density of the Cattle Egret *Bubulcus ibis coromandus* (Boddaert): during 1985, in Tehsil Kharar of the Ropar district (Punjab). *Pavo* 23: 77–84.

Singha, H, Rahmani, A. R., Coulter, M. C. & Javed, S. 2003. Breeding behaviour of the Greater Adjutant-Stork *Leptoptilos dubius* in Assam, India. *J. Bombay Nat. Hist. Soc.* 100 (1): 9–26.

Sivasubramanian, C. 1992. Ecological investigation on the piscivorous birds in Keoladeo National Park, Bharatpur. Ph.D. dissertation, Saurashtra University, Rajkot.

Subramanya, S. 1996. Distribution, status and conservation of Indian heronries. *J. Bombay Nat. Hist. Soc.* 93 (3): 459–486.

Sundar, K. S. G. 2003. Notes on breeding biology of the Black necked stork *Ephippiorhynchus asiaticus* in Etawah and Mainpuri districts, Uttar Pradesh, India. *Forktail* 19: 15–20.

Sundar, K. S. G. & Kaur, J. 2001. Distribution and nesting sites of the Black-necked Stork *Ephippiorhynchus asiaticus*. *J. Bombay Nat. Hist. Soc.* 98 (2): 276–278.

Thomas, B. T. 1986. The behaviour and breeding of adult Magauri storks. *Condor* 88: 26–34.

Thompson, A. L. 1950. Factors determining the breeding season of birds: an introductory review. *Ibis* 92: 173–184.

Urfi, A. J. 1993. Breeding patterns of Painted Storks (*Mycteria leucocephala* Pennant) at Delhi Zoo, India. *Colonial Waterbirds* 16 (1): 95–97.