FORKTAIL 19 (2003): 15-20

Notes on the breeding biology of the Black-necked Stork *Ephippiorhynchus asiaticus* in Etawah and Mainpuri districts, Uttar Pradesh, India

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The breeding biology of the Black-necked Stork *Ephippiorhynchus asiaticus* was studied for three breeding seasons (1999–2002) in Etawah and Mainpuri districts, Uttar Pradesh, India. Twenty-nine pairs were differentiated over the study period in an area of 500 km^2. Nests were found even in densely populated areas, frequently close to roads and habitation. Nest-building began in mid-August, immediately after the monsoon. Egg-laying began in early September, with most chicks hatching by mid-January and fledging by mid-March. Twenty-one pairs raised 50 young successfully to the age of dispersal from natal territories. Most pairs raised two chicks (range: 1–3), but most raised chicks in only one out of the three years, and only one pair successfully raised chicks in two consecutive years. Young usually remained on their natal territories for 14–18 months, but some remained up to 28 months. The population had relatively high productivity and low mortality, suggesting that it is at least stable. Further surveys are needed to ascertain if other healthy populations occur in similar areas of the Gangetic floodplain, and populations of Black-necked Storks outside protected areas need to be accorded increased attention.

INTRODUCTION

The Black-necked Stork *Ephippiorhynchus asiaticus* is classified as Near Threatened (BirdLife International 2001), and it is thought to be declining in India (Luthin 1987, Rahmani 1989). This is thought to be principally due to fragmentation and loss of critical habitat (Luthin 1987, Rahmani 1989), and the removal of nestlings from nests may also be an important threat (Rahmani 1989, Barman and Talukdar 1996). In Australia, Black-necked Storks have recently declined, and this has been attributed largely to degradation and loss of habitat (Dorfman *et al*. 2001). The species is usually found singly or in pairs, rarely in loosely dispersed flocks, and there is nowhere in India where they can be found in large numbers (Ali and Ripley 1989, Rahmani 1989, Gole 1990, Sundar and Kaur 2001).

The majority of published information on the ecological requirements of this species comprises anecdotal notes. The behaviour of the species was first studied in India by Kahl (1970, 1973) and, subsequently, two detailed studies have been carried out on behaviour, feeding, and breeding biology (Ishtiaq 1998, Maheshwaran 1998, see also Maheshwaran and Rahmani 2001, 2002). Information based on intensive surveys has been compiled elsewhere (Rahmani 1989, Gole 1990, Sundar and Kaur 2001). Most of these studies have been carried out inside protected areas. There is no information available on breeding success and productivity in this species. Here I document several aspects of the breeding biology of the species, particularly post-fledging breeding success and productivity, over three breeding seasons in an unprotected, mosaic landscape.

STUDY AREA

I carried out continuous observations of Black-necked Storks in Etawah and Mainpuri districts of Uttar Pradesh, between December 1999 and July 2002 for three breeding seasons (1999–2000, 2000–2001, 2001–2002), and sporadic observations were also made in October 1999. Intensive observations were carried out in the northern part of Etawah and the southern part of Mainpuri, encompassing the area between the towns of Etawah, Saiphai, Karhal, Sauj, Kurra, Saman, Sarsai Nawar, and Baralokpur, in an area of c.500 km^2. The study area lies within the Yamuna drainage basin and forms the western fringe of the Indo-Gangetic floodplain (Gopal and Sah 1993). The climate is described as 'subtropical monsoonic' marked by strong seasonality (Gopal and Sah 1993). Temperatures range from >45°C in March–June to 1°C in November–February. The majority of rainfall falls during the monsoon in August and September. The mean annual rainfall in Etawah district during 1990–2001 was 882 mm.

The topography is flat with the landscape composed principally of crop fields, natural wetlands and marshlands, peppered with habitation and associated structures. The main crops of the region are rice (July–November) and wheat (November–April), plus barley, maize, sugarcane, fruit, and vegetables. A network of canals criss-cross the area. The wetlands of the region are important wintering sites for waterfowl (Scott 1990), and several previously supported wintering populations of the Critically Endangered Siberian Crane *Grus leucogeranus* (Sauey 1985).

METHODS

Observations were carried out along a road route of c.250 km, which was being used to study Sarus Cranes *Grus antigone* (Figure 1). The route was traversed 1–7 times a week (mean=3) for the entire study period, and opportunistic records were also noted. A breeding event was defined as a nest with incubating adults, or adults with pre-fledged young or fledged juveniles. Four nests were located by following adults with nesting material

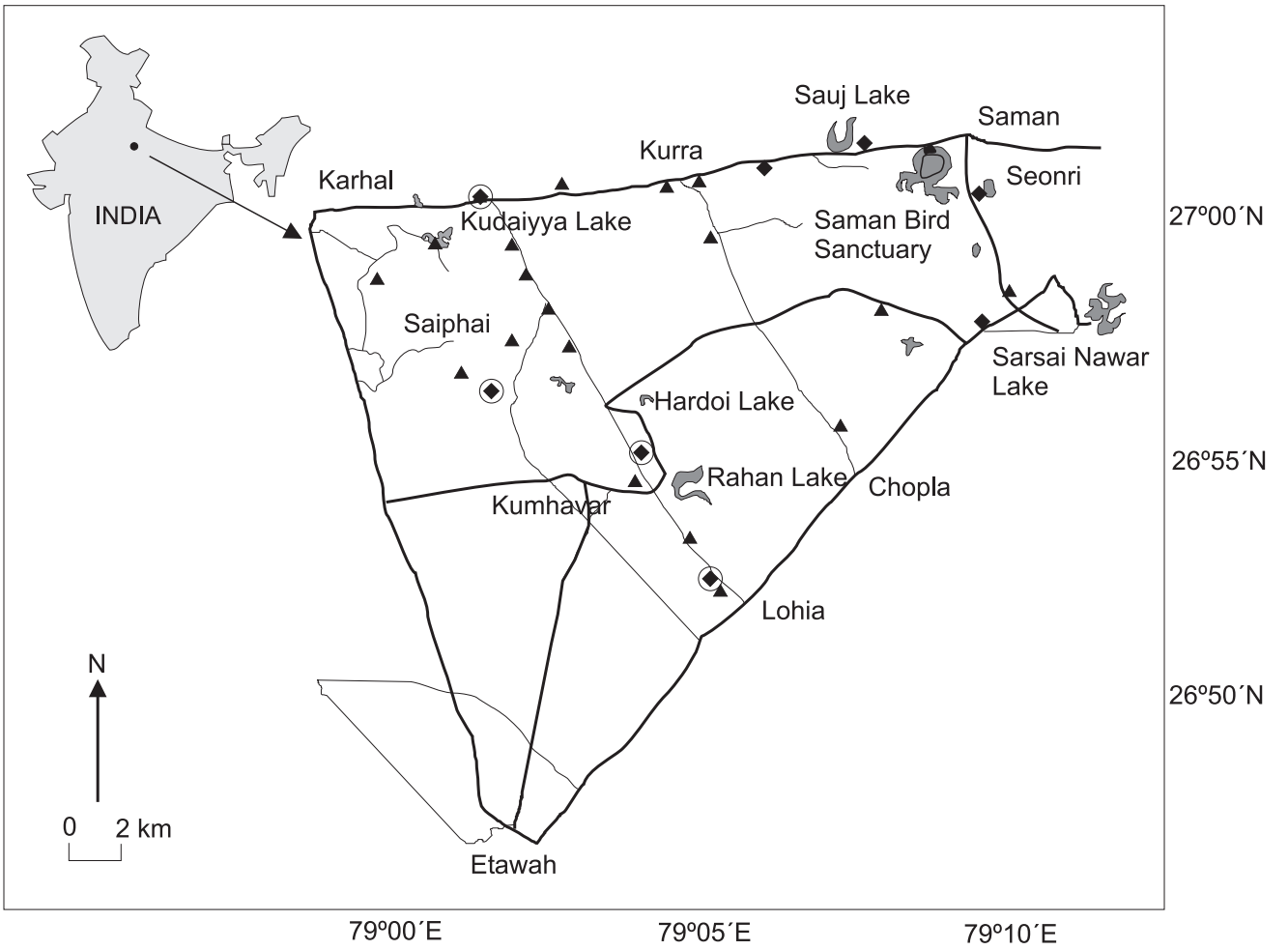

Figure 1. Map of study area showing locations of major towns,wetlands (shaded polygons), metalled roads (lines), and known locations of territorial and breeding pairs of Black-necked Storks. Key to symbols: pairs that fledged young (▲); pairs that did not fledge young (◆); nest locations (circles).

and these nests were observed from the initiation stage. It was not possible to note clutch size, and information given here on breeding success is from the post-fledging stage onwards. Families were distinguishable by location, as most were well-dispersed; the exceptions were distinguished by the number of chicks. For adjacent pairs that did not succeed in raising chicks, the identity and number of pairs was confirmed when they were seen foraging close to each other. Throughout the study period, information on location, identity, and number of pairs and families was continually updated. Pairs were assumed to be faithful to their territories and monogamous.

Hatching months were calculated following Ishtiaq (1998) and Maheshwaran (1998), who reported a 60-day pre-fledging period. The incubation period is still unknown in this species (Hancock *et al.* 1992, Ishtiaq 1998), but for this study, it was assumed to be 30 days, as recorded for the sympatric, solitary-nesting Woolly-necked Stork *Ciconia episcopus* (Ishtiaq 1998). The month of egg-laying was therefore calculated by subtracting three months from the month of fledging. The age of juveniles was estimated by comparison with detailed observations of plumage development of eight juveniles of known age from three families. In all three years, all juveniles were first located and observed within two months of fledging. Determination of hatching and egg-laying months is therefore thought to be accurate to month, and no attempt was made to analyse this information on a finer scale. In 2002, fieldwork stopped in July, and all young alive at this point were assumed to have successfully dispersed. Locations were taken using a Garmin GPS12 Global Positioning System. Distances of nest-trees from habitation, road, wetland and irrigation canals, and heights of nest from the

Table 1. Characteristics of four Black-necked Stork nest-trees.

Nest-tree	Nest height (m)	Habitation	Distance (m) to:		
			Metalled road	Natural wetland	Irrigation canal
Dalbergia sissoo	9	185	187	66	220
Dalbergia sissoo	12	18	690	225	685
Ficus religiosa	13	213	17	36	950
Ficus religiosa	16	15	133	75	850
Mean (SD)	12.5 (2.9)	108 (106)	257 (298)	101 (85)	626 (279)

Table 2. Black-necked Stork breeding success and productivity.

Year of nesting	No. successful pairs	No. chicks fledged		No. chicks dispersed		% of chicks dispersing successfully	Productivity (young raised per territorial female)
		Total	Mean per pair	Total	Mean per pair		
1999	12	30	2.5	28	2.3	93.3	0.97
2000	4	9	2.3	8	2	88.9	0.28
2001	9	14	1.6	14	1.6	100	0.48
Total	25	53		50			
Mean			2.1		2.0	94.3	0.58

ground were noted to the nearest metre using a Bushnell Rangefinder. Daily rainfall was measured at Etawah for 2000 and 2001 using a standard rain-gauge, and rainfall data for 1999 were collected from the office of the District Collector, Etawah.

Annual breeding success in this paper is calculated as the mean number of young that successfully dispersed from their natal territories per successful pair. In some cases, when young birds stayed on in their natal territories for beyond a year, they were regarded to have dispersed successfully when they reached 14 months of age. The number of fledglings produced per year per breeding female is of more demographic significance than the parameters that are usually calculated, namely egg or nest success (Murray 2000). Productivity was calculated as the number of young that dispersed per female in the population each year; this included female birds of all territorial pairs identified in the area.

RESULTS

Nesting

Twenty-nine territorial pairs were differentiated in the study area (Figure 1). Of these, 21 raised young successfully at least once during the study period. Nest-building by both sexes began in mid-August in 2000 and 2001. Four nests were observed in detail: all were constructed of twigs in the upper branches of trees in crop-fields or on dykes that separated fields. The characteristics of nest-trees are summarised in Table 1. Egg-laying was primarily in September and October (Figure 2). In 2001, nesting occurred later and continued until December (Figure 2). The highest incidence of nesting was in 1999, the year with the lowest rainfall.

Breeding success and productivity

Of the four nests observed, only one successfully fledged young. The reason for the failure of others could not be determined. Subsequent analysis of breeding success considers only pairs with successfully fledged young. Of the 29 pairs studied, eight pairs did not succeed in raising chicks even once during the three breeding seasons, although three did nest at least once (Table 2). Of the 53 young that fledged during the study period, 50 (94%) dispersed successfully from their natal territories. All three losses occurred when the young were more than six months of age and it is possible that they had not died, but dispersed earlier than usual. Two were from families with three fledglings each, while the other was from a family with two fledged young. Of the

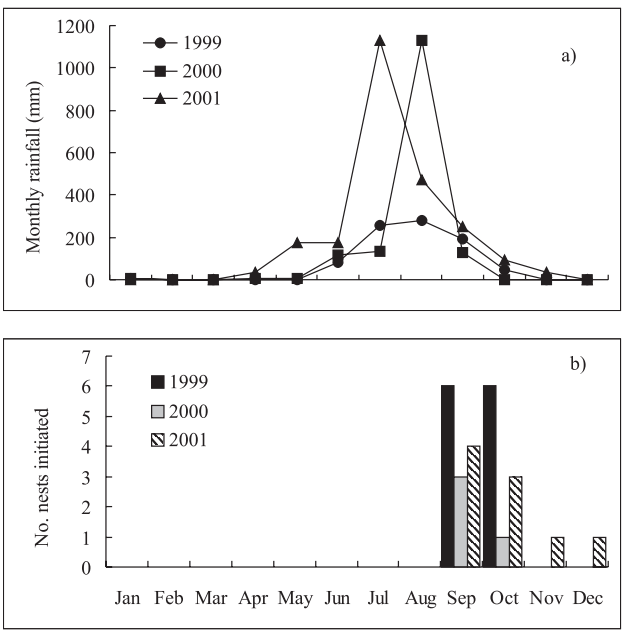

Figure 2. (a) Monthly rainfall in Etawah and Mainpuri districts; (b) Month of egg-laying by Black-necked Storks.

twenty-five successful breeding events observed, three young were raised in six (24%), two were raised in 13 (52%), and one chick was raised in six (24%). Each year, the majority of successful pairs raised two chicks (Figure 3). The number of breeding pairs, and the corresponding productivity, was lowest in 2000–2001 (Table 2). The number of young successfully dispersing per pair was significantly different across years (Kruskal-Wallis test, χ^2=6.22, df =2, P=0.045).

Although the identity of pairs in different years could not be matched with certainty, the location of pairs (and presumed identity) indicated that most (n=17, 58.6%) raised chicks in only one out of the three years, and no pair raised young in all three years. Four pairs managed to raise chicks in two years, but only one of these did so in consecutive years. There was no significant difference between the number of young dispersing successfully from nests initiated one, two or three months after the month of maximum rainfall (Kruskal-Wallis test, χ^2=0.445, df =2, P=0.8).

Other observations

Although adults stopped provisioning young when they reached 3–4 months old, the young remained in their natal territories usually until they were 14–18 months old (but some remained longer, up to 28 months). Young

Table 3. Timing of breeding by Black-necked Stork in India ('?' indicates where approximate month of egg-laying was calculated by subtracting 1–2 months from date when nest was seen with young).

Reference	Month of egg-laying											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oates (1878)	+											+
Reid (1881)									+			
Field (1920)											+?	
McCann (1930)									+			
Kahl (1970)									+	+		
Barman and Talukdar (1996)										+?		
Ishtiaq (1998)									+	+		
Maheswaran (1998)									+			
This study (1999–2001)									+	+	+	+

whose parents nested successfully the following year always left as soon as these nests were initiated. Only young whose parents did not nest or were unsuccessful in raising young remained longer in their natal territories. The exact age of dispersal from natal territories was not ascertained since individual birds could not be identified.

Aggressive interactions between the adults and their fledged young began when the young reached five months old. Six hostile encounters were observed in four families; in each case only the male displayed antagonistic behaviour to the young. Until the young reached 7–10 months, siblings stayed together, usually near to the adults. In one case, the young remained close (<0.5 km) to the nest tree for 14 months, and in another case, the regular foraging area was 3 km away from the nest site until seven months after fledging. Adults were never observed to provision fledged young. Adults were not seen to behave agonistically to neighbouring pairs. Kleptoparasitism was observed twice between siblings, and larger juveniles displaced smaller ones from feeding sites.

DISCUSSION

Nesting habitat

Based on observations in Keoladeo National Park, Rajasthan (KNP; Ishtiaq 1998) and Dudwa National Park, Uttar Pradesh (DNP; Maheshwaran 1998), and a few protected areas in north-east India (Gole 1990), it has been suggested that Black-necked Storks prefer to nest in secluded trees in wetlands or flooded grasslands. However, observations in the Etawah–Mainpuri area clearly indicate that in the absence of persecution and direct disturbance from humans, Black-necked Storks can breed even in areas with intense human activity and population, and are not dependent on trees in wetlands. This situation has not changed over the past 50 years, as Lowther's (1944, p.361) observations of Black-necked Storks in Etawah district noted that they 'nest on the summit of some gigantic *pipal* tree standing by itself in the middle of cultivation, frequently at a considerable distance from water'. He writes in detail of a nest with young in a *pipal* tree 'alongside the Lower Ganga canal a few miles distant from Etawah': this area appears to fall within the region covered during this study. Earlier studies have also suggested that Black-necked Storks may breed only within protected areas (Luthin 1987, Gole 1990), but my observations clearly provide evidence to the contrary.

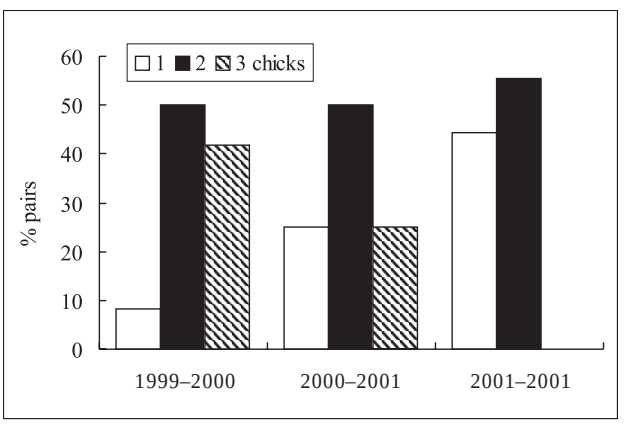

Figure 3. Percentage of pairs of Black-necked Storks successfully raising chicks in each of the three breeding seasons.

Two tree species were used for nesting in this study (Table 1). Other tree species known to be used for nesting by Black-necked Storks include *Acacia nilotica*, *Mitragyna parvifolia*, *Prosopis cineraria*, *Adina cordifolia*, *Acanthocephalus kadamba*, *Bombax ceiba*, *Ficus indica* and *Tamarindus indica* (McCann 1930, Ishtiaq 1998, Maheswaran 1998). In Etawah–Mainpuri, other suitable tree species for nesting included *Ficus benghalensis*, *Prosopis juliflora*, *Mangifera indica*, and *Syzygium cumini*. Several of these were used for nesting by other waterbirds such as Painted Stork *Mycteria leucocephala*, Woolly-necked Stork, and Black-headed Ibis *Threskiornis melanocephalus*. These birds nested in colonies earlier than Black-necked Storks, and their presence may have prevented Black-necked Storks from using such trees. Nest site selection by Black-necked Storks may be driven primarily by proximity to foraging grounds, with a possible preference for permanent natural marshlands.

Timing of breeding

In the study area, Black-necked Storks began nest-building in mid-August, egg-laying from early September, with most chicks hatching by mid-January and fledging by mid-March. This is similar to observations from other studies (Table 3) and consistent with a breeding season of September–December recorded by Grimmett *et al.* (1998). Black-necked Storks in India feed on fish, water birds, snakes, amphibians

and other animals found primarily in wetlands (Ali and Ripley 1989, Elliott 1992, Maheshwaran and Rahmani 2001). Initiation of breeding activity is therefore very likely therefore to be triggered by rainfall, which would ensure formation and maintenance of foraging habitat. In this study, Black-necked Storks began nest construction only after suitable habitat had formed. Similarly, in KNP they start breeding 'when the rain ceases' (Ishtiaq 1998). Data over longer periods are required to determine the effect of rainfall on frequency of nesting and breeding success, but such a study would be complicated by the fact that pairs do not seem to breed every year.

Conservation

The population of Black-necked Storks in Etawah–Mainpuri appears to be at least stable, if not also a source for surrounding populations. This is suggested by the apparent absence of poaching of eggs and young (an important threat elsewhere: Rahmani 1987, Barman and Talukdar 1996), the lack of observations of post-fledging mortality, the observation of only one incidence of adult mortality (Sundar in press), and the observation of relatively high reproductive success.

The species requires wetlands with low levels of disturbance for feeding and nesting (Ishtiaq 1998, Maheswaran 1998, Dorfman *et al*. 2001, Maheshwaran and Rahmani 2001, personal observations). Both are presently prevalent in the study area. The well-maintained and extensive canal system and inundated crop fields in this predominantly agricultural belt provide additional habitats for foraging storks. However, intensive conversion of remaining natural habitats to agriculture in Uttar Pradesh (Sethi 2001, Sundar 2002) will certainly have an adverse effect on this species.

The discovery of this apparently healthy population provides hope for the species. However, further surveys are needed to determine whether there are other similar areas in the Gangetic floodplain or whether habitat degradation and human persecution are the norm. Such surveys could exploit the fact that young remain on their natal territories for 14–18 months, often close to the nest trees, and hence rapid surveys can determine approximate breeding areas at any time of year (see Sundar and Kaur 2001). However, in drier areas like Rajasthan and parts of Madhya Pradesh, storks may carry out long-distance foraging forays (Rahmani 1989) and breeding areas may not be directly determinable from observations of foraging families.

Alongside preservation of crucial habitat for Black-necked Storks, further ecological studies on the species are needed, focusing particularly on habitat requirements and determinants of breeding success, and the effect of human activities.

ACKNOWLEDGEMENTS

The observations were carried out while carrying out fieldwork under the project 'Impact of Land Use Change on the Habitat and Ecology of the Indian Sarus Crane (*Grus a. antigone*) in the Indo-Gangetic Flood Plains' of the Wildlife Institute of India (WII), and I thank the Director and B. C. Choudhury for facilities and infrastructure. Drs F. Ishtiaq, G. Maheswaran and A. R. Rahmani, and P. Gole readily provided reports, papers and copies of theses, and I thank them for their help. I am grateful for the library support extended by M. S. Rana (W.I.I.), and to S. Rokkam for the donation of the GPS. G. W. Archibald kindly provided the thesis of R. Sauey at very short notice. R. Chauhan and family are thanked for making the stay in Etawah comfortable and congenial. R. Chauhan, S. Chauhan, D. Singh and A. Verma assisted in fieldwork. At W.I.I., P. Lal prepared the map and D. Pundir assisted in preparation of the manuscript and I thank them both. I am grateful to B. C. Choudhury and Drs G. Maheswaran, B. Pandav, A. R. Rahmani, and K. Sivakumar for discussions and providing useful comments that improved a previous draft. I also thank an anonymous referee for comments that improved that manuscript.

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