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Breeding Ecology of the Endangered Black-bellied Tern (*Sterna acuticauda*) in Eastern India and Implications for Conservation

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Abstract.—The global population of Black-bellied Tern (*Sterna acuticauda*) is declining, and insufficient information is available on its breeding ecology. The aim of this study was to record its breeding ecology and factors affecting breeding success along the Mahanadi River in Odisha, eastern India. Breeding was observed during January-April 2018, with peak activity in March. Among 24 nests recorded on seven sandy islands, only 11 nests successfully produced chicks. Factors affecting survival of nests were flooding due to anthropogenic changes in water levels (54%), predation (31%), and trampling (15%). Dredging of canals that use water from the river is recommended to reduce fluctuations in water levels. Targeted long-term studies along the entire length of the Mahanadi River and other large rivers can aid in identifying other breeding sites and ongoing threats to this rare and endangered species. Outreach in communities near breeding sites and recruiting of local residents as nest guardians can also help in protection of nesting sites. *Received 9 October 2018, accepted 25 February 2019.*

Key words.—Black-bellied Tern, breeding ecology, eastern India, hatching success, Mahanadi River, nest flooding, *Sterna acuticauda*.

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The Black-bellied Tern (*Sterna acuticauda*) is a globally endangered waterbird species currently confined to Bangladesh, India, Myanmar, Nepal and Pakistan; formerly also found in Cambodia, China, Laos, Thailand, and Vietnam (Goes *et al.* 2010; Sykes 2010; BirdLife International 2017). This riverine species is more vulnerable than other tern species to ongoing threats to its habitat, including industrial pollution, dam construction, extraction of sand and gravel, over-harvesting of wetland products, and human disturbance (Sykes 2010; Rahmani 2012; BirdLife International 2017). Flooding and egg collection also have negative effects on breeding success (Goes *et al.* 2010; Rahmani 2012; BirdLife International 2017). Although there are no reliable estimates of total population, the species is thought to be declining at an alarming rate worldwide (Mundkur 1988; Li *et al.* 2009; Sykes 2010; BirdLife International 2017).

Among all countries within the known range of the Black-bellied Tern, India holds the largest area. The species is found along large rivers throughout the country except the far western, northern, and north-eastern regions (Rahmani 2012; Fig. 1). Despite its wide distribution in India, published information on its breeding sites is limited to Kaziranga National Park, Assam (Barua and Sharma 1999), Bharathapuzha River, Kerala (Neelakantan *et al.* 1993; Eldos *et al.* 2002; Sushanthkumar 2004), Hidkal dam, Karnataka (Rahmani 2012), Mahanadi River and Chilika Lake, and Odisha (Rahmani and Nair 2012; Dev 2013). Birds in breeding plumage have also been reported in National Chambal Sanctuary, Madhya Pradesh (Pramanick 2016), and photographs from other sites have been posted online (Oriental Bird Club 2019). Unfortunately, a recent survey by the Salim Ali Centre for Ornithology and Natural History did not locate this species along the Bharathapuzha and Cauvery rivers (Marimuthu 2018). Despite the fact that the species faces numerous threats during the breeding period in India, very little quantitative information is available on its breeding ecology (Rahmani 2012). Our objectives were to describe the breeding ecology of the species in eastern India and to identify threats.

Methods

Study Area

The study area lies between 20° 22′ 00″ N, 85° 24′ 00″ E and 20° 25′ 00″ N, 85° 56′ 00″ E, covering a

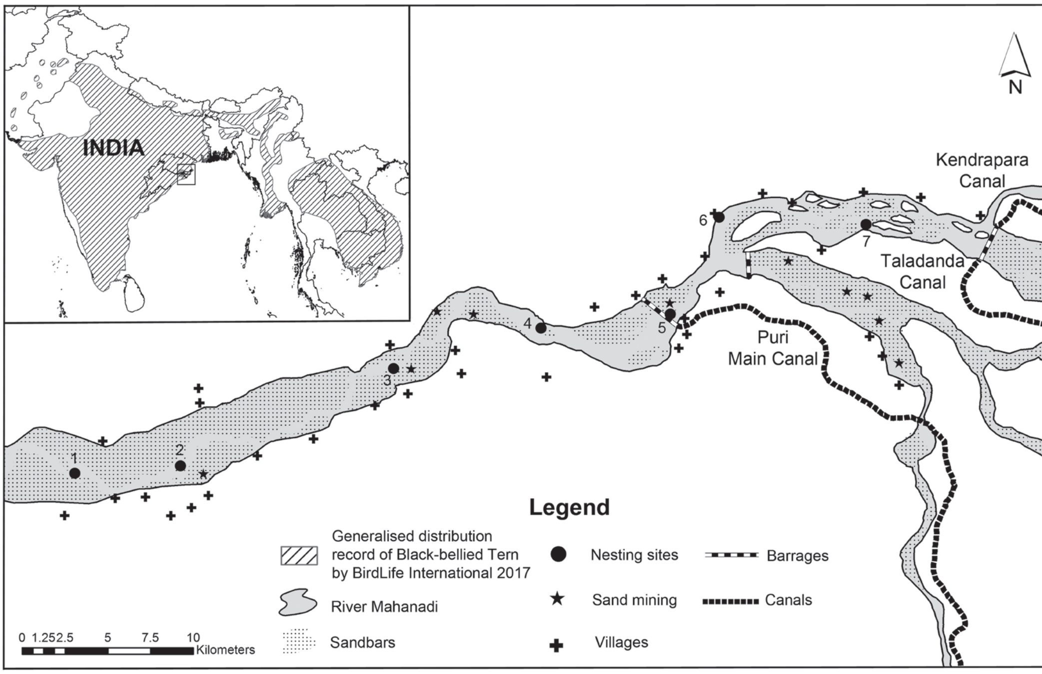

Figure 1. Global distribution of the Black-bellied Tern (*Sterna acuticauda*) (inset) and study site along the Mahanadi River in Odisha, eastern India (serial number of the nesting sites: 1 = Botalama; 2 = Bheda; 3 = Jatamundia; 4 = Kainmundi; 5 = Mundali; 6 = Kakhadi; 7 = Chahataghat).

length of 58 km along the Mahanadi River within an anthropogenic zone in Odisha, eastern India (Fig. 1). Within the study area, two barrages (Mundali barrage at Mundali and Mahanadi barrage at Jobra) and three canals (Taladanda canal, Puri main canal, and Kendrapara canal) have been constructed for control and utilization of the river water. With respect to availability of water throughout the year, this is one of the most important sites for waterbirds in Odisha: 58 species of waterbirds, including 23 species of winter visitors, have been reported from this area (Kar and Debata 2018). There are 35 villages situated along both sides of the river, whose livelihoods largely rely on year-round fishing and agricultural activities. Approximately ten places in the study area are used for sand mining. The climate of the area is tropical, with three distinct seasons: summer (March-June), monsoon (July-October), and winter (November-February). The annual mean temperature of the area is 26.8 °C, ranging from 12 °C in January to 42 °C in May.

Data Collection and Analysis

While monitoring Indian Skimmers (*Rynchops albicollis*) in the study area in January-July 2018, we surveyed the available islands for nesting Black-bellied Terns. After locating nests, we monitored them from a safe distance using binoculars to confirm species identity and to record nest making, guarding, or incubating eggs. We also counted the number of birds at each site on each day. We measured the depth and diameter of all nests and estimated their distance from the nearest water and vegetation. We marked each nest with a numbered bamboo stick about 1.2 m away for further monitoring, following Sathiyaselvam and Balachandran (2007). For each nest, we recorded the laying date of each egg, the completed clutch size, and hatching dates. We calculated the incubation period for each clutch as the difference between the laying date of the first egg and the hatching date of the first chick. We monitored all the nesting sites each day at the same time, either in early morning or late afternoon, minimizing disturbance. We recorded the temperature and humidity of the study area on each day at 12:00 hr.

We considered a nest as successful if at least one egg hatched and calculated the apparent hatching rate as the proportion of successful nests. In cases where a nest failed, we tried to identify the cause of failure by examining the nest and its surroundings. We considered a nest as flooded when its bottom was wet and/or the eggs were totally or partially submerged. When damaged eggs were found and footprints of a human or an animal were near the nest, we considered the nest to be trampled. When a nest was damaged with fresh animal signs and fragments of eggshell nearby, we considered the nest to be depredated. We also made informal discussions with local people regarding whether they collect eggs or not.

We measured the length and breadth of flooded eggs to the nearest 0.01 mm using digital calliper, and calculated egg volume (V_e) and Shape Index (*SI*) following Coulson (1963):

$$V_e = K \times L \times B^2 \text{ and } SI = (B/L) \times 100,$$

where $K = 0.482$ (Calvo 1994; Hanane *et al.* 2010), L is egg length and B is egg breadth.

We could not effectively monitor whether the chicks hatched in a particular nest (herein referred as "early survivors") further survived to fledgling or died as they frequently moved far away from their nests within 2-3 days after hatching. However, every day we intensively searched for all the early survivors and counted their number to know whether they were alive, dead, or missing. Whenever any dead chick was encountered, we carefully observed it to know the possible cause of death and later buried it under the sand to avoid recounting. Accordingly, we estimated the apparent chick survival rate as the proportion of the fledglings to the total number of chicks hatched. We considered the chicks as fledglings when they were able to fly but had not developed adult plumage.

RESULTS

Nesting Sites

Black-bellied Terns were found nesting on seven islands. Most nesting sites were temporary islands with areas of 0.9-42 ha (mean 15.7 ± 5.6 SE), situated 0.08-1.6 km (mean 0.58 ± 0.19 SE) from the mainland and 0.18-1.9 km (mean 1.01 ± 0.27 SE) from the nearest human habitation (Table 1). The nesting islands were sandy and mostly barren, with sporadic patches of *Sachrum spontaneum*, *Mimosa pudica*, *Bergia capensis*, and *Cleome viscose*.

Breeding Phenology

Courtship and mating behavior of Black-bellied Terns started during the second half of January 2018, with nest-making from 7 February-24 March 2018 (Fig. 2). Egg-laying was observed from 9 February-28 March (48 d), with a peak during March (60%, $n = 36$ eggs; Fig. 2). Hatching was observed from 1 March-14 April (45 d), with a peak during March (77%, $n = 23$ chicks; Fig. 2). Incubation periods ranged from 19-21 d (mean 20.4 ± 0.12 SE). During the breeding season, the mean atmospheric temperature and relative humidity at 12:00 hr within each five-day period varied from 31.2-38.8 °C (mean 35.9 ± 0.5 SE) and 24-60% (mean 42 ± 3 SE), respectively (Fig. 2). Nesting islands of Black-bellied Terns were also used by nesting Indian Skimmers, River Terns (*Sterna au-*

Table 1. Nesting sites, number of nests, and factors affecting nesting success of Black-bellied Tern (*Sterna acuticauda*) along the Mahanadi River in Odisha, eastern India during February–April 2018. Serial number (SI No.) indicates locations in study area (Fig. 1).

SI No.	Location	Area (ha)	Distance from mainland (km)	Distance from human habitation (in km)	Number of nests	Cause of nest failure				Proportion of total
						Flooding	Predation	Trampling	Total	
1	Botalama	19.0	1.62	1.95	4		1		1	25%
2	Bheda	17.7	0.65	1.91	2					
3	Jatamundia	23.2	0.64	1.26	2					
4	Kainmundi	41.9	0.301	0.79	2	2			2	100%
5	Mundali	1.5	0.44	0.51	5	1	2		3	60%
6	Kakhadi	0.9	0.08	0.18	6	2		2	4	67%
7	Chahataghat	5.4	0.30	0.49	3	2	1		3	100%
	Total				24	7	4	2	13	54%

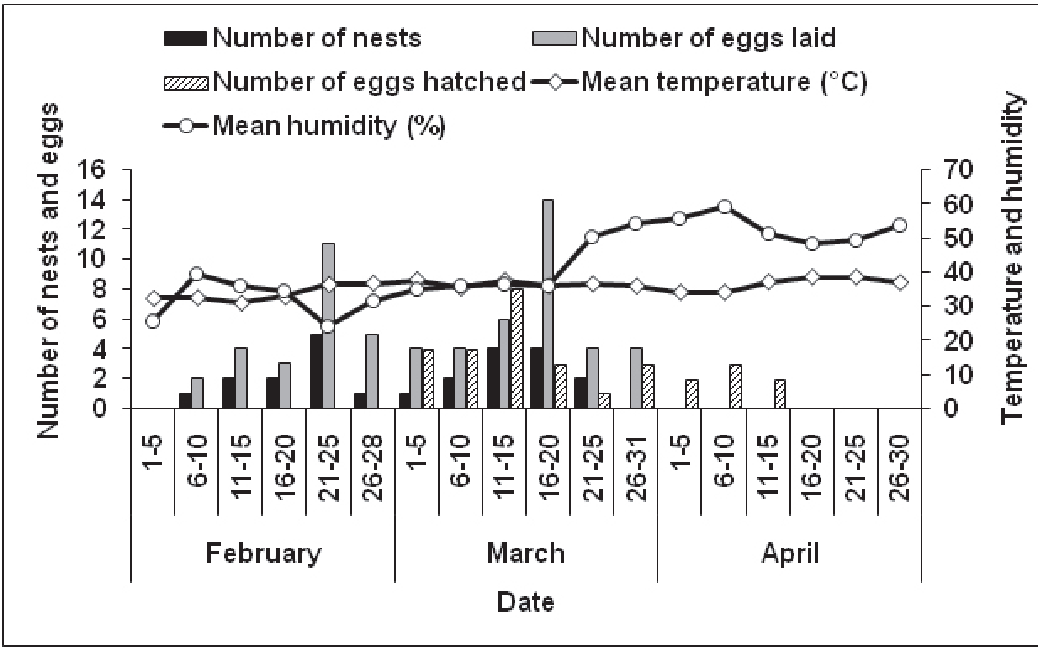

Figure 2. Phenology of nest initiation, egg laying, and hatching of Black-bellied Terns (*Sterna acuticauda*) from February-April 2018 along the Mahanadi River in Odisha, eastern India.

rantia), River Lapwings (*Vanellus duvaucelii*), and Little Pratincoles (*Glareola lactea*).

Distribution and Abundance of Nests

A total of 24 nests of Black-bellied Tern were recorded (Table 1). Nests were shallow depressions in the sand with diameters of 14-20 cm (mean 17.4 ± 0.2 SE) and depths of 3.8-5.2 cm (mean 4.2 ± 0.1 SE). Nests were located 1-30 m (mean 13.5 ± 1.5 SE) from water and 0.2-37 m (mean 16 ± 2 SE) from vegetation. More than 70% of nests were within 20 m of water and vegetation (Fig. 3).

Clutch Size and Egg Dimensions

Clutch size varied from one to three eggs (mean 2.54 ± 0.12 SE). Fourteen clutches had three eggs, nine clutches had two eggs, one clutch had only one egg but was flooded and may not have been complete. Egg length and breadth varied between 3.07-3.24 cm (mean 3.15 ± 0.02 SE) and 2.34-2.48 cm (mean 2.39 ± 0.01 SE), respectively. Calculated egg volume varied between 8.10-8.85 cm^3 (mean 8.69 ± 0.17 SE) and the Shape Index varied between 73.5-77.3 (mean 75.9 ± 0.50 SE).

Nest survival Rates

Among the 24 monitored nests, only 11 nests containing 30 eggs successfully produced chicks, yielding an apparent hatching rate of 46%. The main factors affecting nesting success were flooding (54%), predation (31%), and trampling (15%; Table 1). Based on tracks and signs near to nests, predation was attributed mainly to stray dogs and possibly Jackals (*Canis aureus*). Trampling was attributed to buffalos and humans (one nest each). Among all nesting sites, the hatching rate was 100% only at Bheda and Jatamundia (Table 1). Among the 30 chicks hatched in 11 nests, 19 reached the fledgling stage, indicating an apparent chick survival rate of 63%. The remaining 11 early survivors were found dead away from their nests. We could not further locate the fledglings, but we sighted juveniles on two occasions, 8 April and 23 April 2018, at Mundali and Kainmundi, respectively.

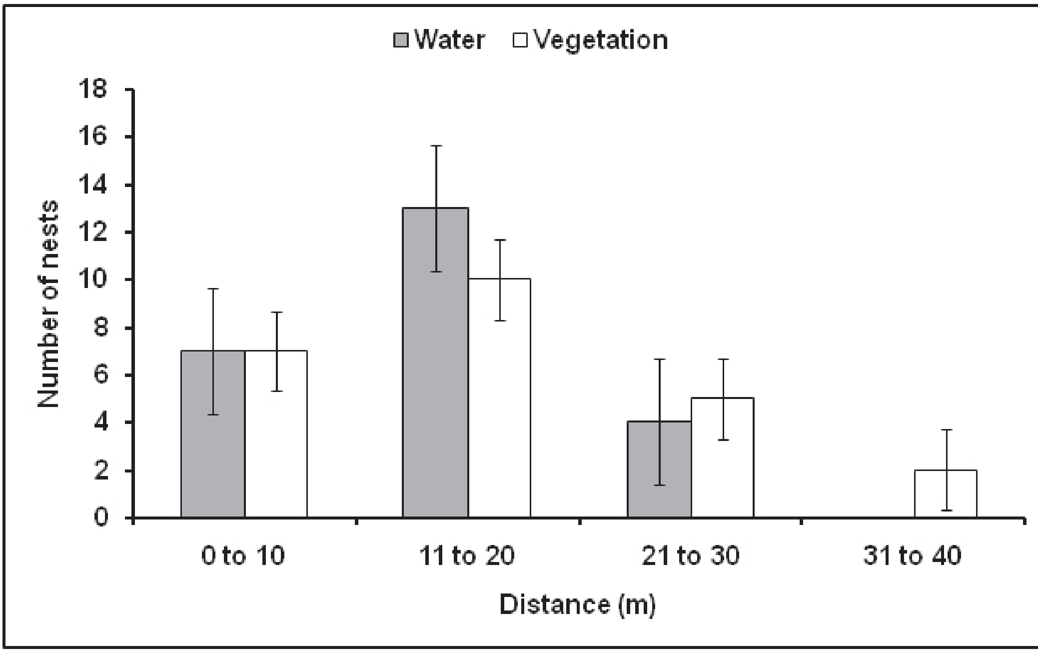

Figure 3. Frequency distribution of Black-bellied Tern (*Sterna acuticauda*) nests in relation to distance from water and vegetation.

DISCUSSION

Egg laying and hatching of Black-bellied Terns along the Mahanadi River occurred in the summer season from February to April with a peak during March. This conforms to other reports (i.e., during April) in north eastern India (Kaziranga National Park; Barua and Sharma 1999), southern India (Bharathapuzha River in Kerala; Neelakantan *et al.* 1993; Eldos *et al.* 2002; Sushanthkumar 2004), March in Cambodia (Claassen 2004), and February in Myanmar (Claassen 2017). We frequently observed incubating birds flying low over water and soaking their bellies during hot hours of the day, probably either to cool their eggs (Grant 1982; Neelakantan 1953) or to relieve heat stress on their bodies (Amat and Masero 2004, 2007). We also observed chicks > 7 d old sheltering in vegetation and moist areas near water during hot afternoons. Selecting nest sites close to water and vegetation may be an adaptation to avoid heat stress.

Flooding was the major factor affecting hatching success, followed by predation and trampling. The three canals originating from the study area were originally designed during the late 18th century for irrigation and transportation but were subsequently extended for industrial and urban uses. They have been degraded by siltation, erosion of soil from nearby areas, dumping of household wastes, and other anthropogenic factors (Prusty and Biswal 2017). Consequently, their capacity has been severely reduced, especially during the summer season. Irrigation Department authorities have informed us that they frequently close the outlet gates of the Mahanadi and Naraj barrages to raise the water level in the river so that sufficient water can pass through the canals. This submerges the temporary islands on which Black-bellied Terns and other ground-nesting birds nest. Flooding of the nesting islands was recorded seven times during our study. We also observed that grasses and shrubby vegetation grew on the islands after they were exposed, and that local people took advantage of this for grazing their livestock (buffalos). Low water levels also allowed stray dogs and other predators to gain access to the nesting islands. We observed predatory birds like Gray Herons (*Ardea ci-*

nerea), Brown-headed Gulls (*Chroicocephalus brunnicephalus*), and Black Kites (*Milvus migrans*) in the study area. We also observed that Black-bellied Terns left their eggs and chicks unattended during anthropogenic activities such as fishing and the presence of buffalos and stray dogs, increasing the risk of heat stress (Claassen *et al.* 2018).

In summary, loss of nests is a major issue at our study site as well as at other sites throughout the range of the Black-bellied Tern (Rahmani 2012; Rahmani and Nair 2012; BirdLife International 2017). Consequently, it is crucial to protect the nesting sites from human-induced threats. All the Black-bellied Tern nesting sites in our study area are situated within the area regulated by the Irrigation and Revenue Department. Threats from flooding could be minimized by dredging the canals and their mouths, so that water could pass through them without increasing the water level in the river. Although we did not observe any incidents of egg collection by local people, trampling by livestock could be minimized by involving the local communities. Claassen (2004, 2017) recommended activities to make local communities aware of the conservation importance of sandbar-nesting birds, and to engage community members as nest-guards for river-nesting birds in Cambodia. These recommendations could also be useful in our study area. Movement of stray dogs in the nesting sites could be controlled by blocking access. Sand mining areas should be regulated by law enforcement. These proposed activities would not only aid in long-term conservation for Black-bellied Terns, but also for other threatened waterbirds, like the Indian Skimmer, River Tern, and River Lapwing that experience similar threats. A targeted survey of all areas used by these species could improve our knowledge of their breeding ecology and factors affecting their breeding success and promote their conservation.

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