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Nesting Ecology and Habitat Preference of the Masked Finfoot (*Heliopais personatus*) in Sundarbans, Bangladesh

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Abstract.—The Masked Finfoot (*Heliopais personatus*) has a global population estimated at 1,000 individuals, but very little is known about its ecology. Therefore, the nesting ecology of the Masked Finfoot was studied in the Sundarbans of Bangladesh between 2011 and 2014, and compared to nesting observations from the same area made in 2004. A total of 25 nests were detected in 2011-2014: 56% ($n = 14$) on blinding mangrove (*Excoecaria agallocha*), 36 % ($n = 9$) on sundri (*Heritiera fomes*) and 8% ($n = 2$) on cannonball mangrove (*Xylocarpus granatum*). Factor analysis revealed that 2004 nest characteristics differed from subsequent years. The 2011-2014 nests were built on the periphery of vegetation along narrow creeks of 12.66 ± 3.54 m and located 1.78 ± 0.53 m above water level at high tide. Diameter of nesting tree (2004 = 16.68 ± 5.82, 2011-2014 = 34.19 ± 3.96), nest depth (2004 =16.88 ± 3.09, 2011-2014 = 13.28 ± 3.32) and creek width (2004 = 21.26 ± 9.09, 2011-2014 =12.66 ± 3.54) was significantly different between 2004 and 2011-2014. Reasons for changes in nesting locations are important to determine given the conservation status of the species and altering conditions in the Sundarbans. *Received 4 March 2017, accepted 22 July 2017.*

Key words.—Bangladesh, conservation, endangered species, *Heliopais personatus*, Masked Finfoot, nesting ecology, Sundarbans.

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Bangladesh holds an important population of the endangered Masked Finfoot (*Heliopais personatus*), which is distributed from northeast India, Myanmar, Thailand, Cambodia, Laos and Vietnam to Peninsular Malaysia and Sumatra and Java, Indonesia (Duckworth *et al.* 2016). This species has been declining throughout its range due to habitat destruction, increasing disturbance to riverine forests, hunting and collection of eggs and chicks (Duckworth *et al.* 2016). The population of mature birds is now thought to be fewer than 1,000 individuals (Duckworth *et al.* 2016). In Bangladesh, the Masked Finfoot is largely confined to mangroves in the eastern half of the Sundarbans, mainly in the freshwater (low salinity zone with < 5 ppt salinity level) and moderately saline (5-15 ppt salinity level) zones in the Khulna, Chandpai and Sarankhola ranges. There are no confirmed records of the species from the Satkhira range (> 15 ppt salinity level) in western parts of the Sundarbans (Gani 2005; Neumann-Denzau *et al.* 2008).

Very little is known about the natural history of Masked Finfoots in Bangladesh. The first nesting observation of this species was reported from the Sundarbans in 2004 during a week-long survey that covered 60 km^2 or 1% of the total area of the Bangladesh Sundarbans; during this survey 19 nests were recorded, suggesting that the population was widely dispersed across the mangrove ecosystem (Neumann-Denzau *et al.* 2008).

Our objective was to study the nesting ecology of the Masked Finfoot and compare our results with previous findings to understand if any change in nesting conditions was apparent.

Methods

Study Area

The Sundarbans (21° 30′ to 22° 30′ N, 89° 00′ to 89° 55′ E) is located in the southwestern corner of Bangladesh and extends across Khulna, Satkhira, Bagerhat, Patuakhali and Barguna districts. It is a part of the Ganges delta (80,000 km^2) and forms the largest single block of halophytic mangrove forest in the world (Sarker *et al.* 2016). A major portion of this forest is inundated by tides twice a day, while the freshwater flow increases during the breeding season of Masked Finfoot between June and September (Neumann-Denzau *et al.* 2008) and decreases during the dry season between October and May (Sarker *et al.* 2016). Mean annual precipitation of the Sundarbans is 170 cm (Range = 147.4-226.5 cm), and mean maximum annual temperature is between 29.4°-31.3 °C (Range = 9.3°-40.0° C) (Sarker *et al.* 2016).

Previous studies (Khan 2003; Gani 2005; Neumann-Denzau *et al.* 2008) and recent records of Masked Finfoots in the Sundarbans indicate that the species mainly occurs on the east side of the Sibsa River. The present study took place primarily in the eastern Sundarbans in the Sarankhola range, but also partly in the Khulna and Chandpai ranges (Fig. 1).

Nest Surveys

A total of 344 km of waterways were systematically surveyed for nests, with 224 km covered in June-August in 2011 and an additional 120 km covered in June-July of 2013 and 2014. The study was conducted in waterways that were not surveyed before, as well as all previously identified nesting creeks (Neumann-Denzau *et al.* 2008) and channels between 5 m and 500 m width.

Survey tracks for each year and locations of all occupied and unoccupied nests were recorded with a hand-held Geographical Positioning System (GPS) receiver with an accuracy of 1 m. Observations were made and recorded using 10x42 binoculars, a 25-50x spotting scope and a DSLR camera with a 300-mm lens.

Nesting Data Collection

We recorded the following measurements at each occupied and unoccupied nest site with a standard measuring tape: nest height above water level (measured from the high tide mark to the base of the nest), nesting tree diameter at high water level, nest stream diameter (the widest part of the branch with the nest), nest depth (vertical depth of the interior of the nest), nest diameter (the total diameter of the nest measured as distance between the external rims of the nest), nesting creek width (width of the creek or stream) and distance of nesting tree from bank (horizontal distance of the base of the tree from the dry bank of the creek). Nesting tree height and the angle between nesting branch and water surface were visually estimated. We identified unoccupied nests (nests without adults, eggs or chicks) as Masked Finfoot nests since no other avian species in the Sundarbans show the nest characteristics mentioned above and based on the previous experience of the observers.

Statistical Analysis

Factor analysis was conducted on the following variables: nest height from water level, angle, tree diameter, nest stream diameter and creek width to summarize patterns of variation (McGarigal *et al.* 2000; Sokal and Rohlf 2012). Scores derived from variables were plotted in relation to Factors 1 and 2 and were categorized by year to visualize nest-site patterns between years. We conducted one-way ANOVAs with variables that showed strong communality association between individual

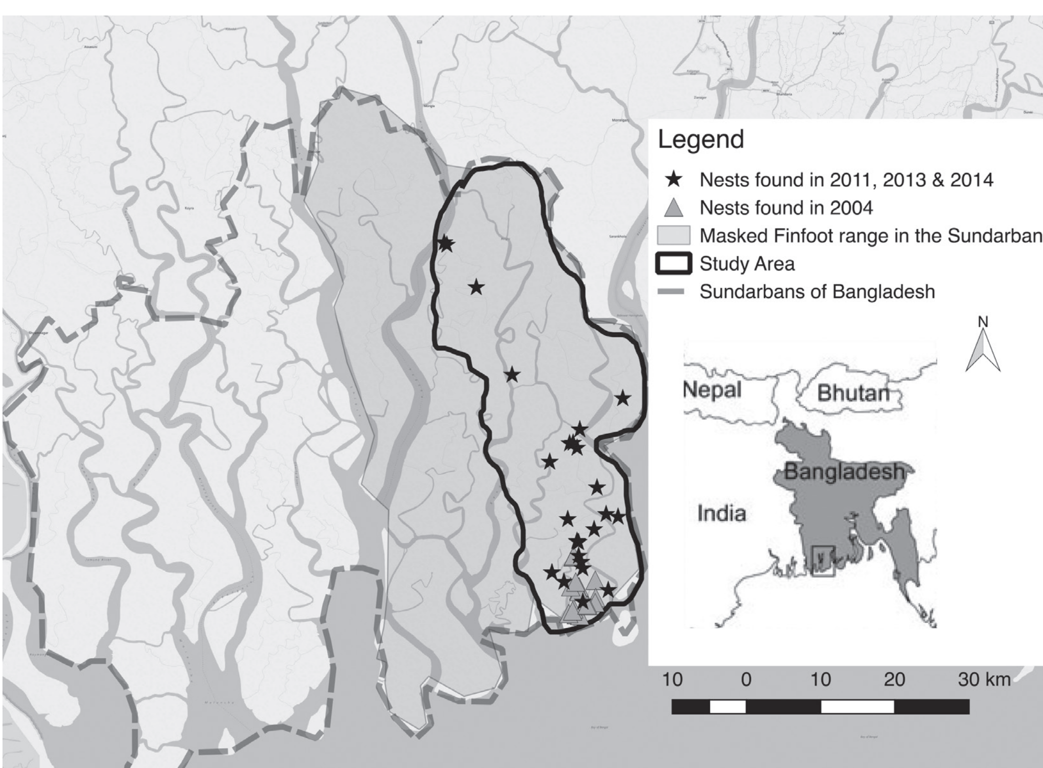

Figure 1. Map of the Sundarbans of Bangladesh showing the study area and the known range of Masked Finfoot and its nest locations recorded in 2004, 2011, 2013 and 2014.

variables and factors (McGarigal *et al.* 2000; Sokal and Rohlf 2012). Communality values higher than 0.5 indicate strong association between a given variable and a given factor, with values that are closer to 1 indicating very strong influence of these variables on a given factor (McGarigal *et al.* 2000).

In 2011, 2013 and 2014, we recorded widths of all surveyed waterways. We then divided all creek widths into two groups (number of creeks surveyed within the width between 5 and 25 m and number of creeks surveyed outside the 5 to 25-m width range). Pearson's Chi-square test was used to test the hypothesis that Masked Finfoot nests were not uniformly distributed in all creeks with different widths. All statistical analyses were performed using the program Minitab (Minitab, Inc. 2004).

RESULTS

Nests and Nesting Sites

A total of 25 nests were recorded comprising 12 in 2011, 6 in 2013 and 7 in 2014. Fifty-six percent of nests (n = 14) were on blinding mangrove (*Excoecaria agallocha*), 36% (n = 9) on sundri (*Heritiera fomes*) and 8% (n = 2) on cannonball mangrove (*Xylocarpus granatum*) trees. All nests were built on the outer edge of vegetation along the narrow creeks of 12.66 ± 3.54 m and located 1.78 ± 0.53 m above water level at high tide (Table 1). Nesting trees, on average, were located 2.57 ± 1.84 m from the bank at high tide. Seventy-five percent of all waterways surveyed in 2011 fell within the width between 5 and 25 m (χ^2 = 4.65, df = 1, P = 0.03, total n = 107 waterways); all 12 nests were found within the waterway width range of 7-19 m.

All nests were above water level during spring tide and neap tide (first and third quarter of the lunar cycle). The angle between creek water surface and nest-trunk was 45.00° ± 8.78°. Average nesting tree height was 6.42 ± 2.75 m with 43.76 ± 19.95 cm tree diameter at high water level and 14.29 ± 8.83 cm nest stream diameter (the widest part of the branch with the nest) (Table 1). All nests were open-bowl shaped with a 34.19 ± 3.96 cm diameter and 13.28 ± 3.32 cm height (Table 1). Twenty percent (n = 5) of the nests were built in nest fern (*Asplenium* sp.), 4% (n = 1) on an unidentified epiphyte and 76% (n = 19) on tree branches.

Table 1. Variation in nest characteristics for all recorded nests of the Masked Finfoot in the Sundarbans of Bangladesh. Values are mean ± SD (*n*).

Variables	2004	2011	2013	2014	2011-2014 Combined
Nest height above water level (m)	1.82 ± 1.10 (19)	1.60 ± 0.56 (12)	1.56 ± 0.15 (6)	2.12 ± 0.57 (7)	1.78 ± 0.53 (25)
Nest depth (cm)	16.88 ± 3.09 (17)	13.52 ± 3.91 (12)	12.70 ± 3.23 (6)	13.40 ± 2.19 (5)	13.28 ± 3.32 (23)
Nest diameter (cm)	35.35 ± 4.40 (17)	35.33 ± 4.72 (12)	32.50 ± 1.22 (6)	33.50 ± 3.85 (6)	34.19 ± 3.96 (24)
Angle °	49.2 ± 15.00 (19)	45.41 ± 10.96 (12)	43.33 ± 8.16 (6)	45.71 ± 4.49 (7)	45.00 ± 8.66 (25)
Tree diameter at water level (cm)	16.68 ± 5.82 (19)	51.90 ± 18.83 (12)	39.38 ± 17.06 (6)	20.00 ± 1.00 (3)	43.76 ± 19.95 (21)
Tree height (m)	n/a	6.13 ± 3.49 (11)	8.72 ± 5.83 (6)	7.66 ± 2.08 (3)	6.42 ± 2.75 (20)
Nest stream diameter (cm)	8.00 ± 3.88 (19)	11.40 ± 5.45 (12)	22.11 ± 13.88 (6)	12.25 ± 1.06 (6)	14.29 ± 8.83 (24)
Distance of nesting tree from bank (m)	n/a	2.55 ± 2.26 (11)	2.08 ± 1.35 (6)	3.66 ± 0.57 (3)	2.57 ± 1.84 (20)
Creek width (m)	21.26 ± 9.09 (19)	12.70 ± 3.81 (12)	11.65 ± 3.24 (6)	13.42 ± 3.59 (7)	12.66 ± 3.54 (25)

Factor Analysis of Nest Site Variables

The data for all 44 nest sites (2004, 2011, 2013 and 2014) indicated that nest site characteristics were distinct in 2004 compared to 2011-2014 (Fig. 2). Factors 1, 2 and 3 accounted for most of the variability (McGarigal *et al.* 2000; Table 2). Communality values were more than 0.5 for all variables (except nest stream diameter) indicating a strong influence of these variables in influencing each of the three factors (McGarigal *et al.* 2000; Table 2).

Subsequent ANOVAs indicated significant differences in tree species, tree diameter, nest depth and creek width. Nesting tree species varied significantly between years, and sundri dominated in 2004 compared to all other years (Fig. 3). Nesting tree preference was distinctly different in 2004 with 79% ($n = 15$) of the nests constructed on sundri and only one nest built on blinding mangrove, whereas in later years (2011, 2013 and 2014) the blinding mangrove was the dominant nesting tree with 56% ($n = 14$) of the nests.

Tree diameter changed significantly from 2004 to 2011-2014; trees with larger diameters were selected in 2011 and 2013 (one-way ANOVA, F = 19.94, $P < 0.001$; Fig. 4). The depth of nests also changed significantly from 2004 to 2011-2014, with deeper nests observed in 2004, followed by much shallower nests in subsequent years (one-way ANOVA, F = 4.0, $P = 0.015$; Fig. 4). Nests were located in smaller creeks after 2004 and showed similar patterns in subsequent years (one-way ANOVA, F = 9.17, $P < 0.001$; Fig. 4).

Discussion

Masked Finfoot nests were primarily built on sundri in 2004 (Neumann-Denzau *et al.* 2008) and on blinding mangrove and sundri in 2011, 2013 and 2014 with the maximum number of nests on blinding mangrove. Thus, the results of this study indicate that there has been a shift in habitat preference suggested by the change in tree species used for nesting, although we lack data on structural composition of the vegetation from sundri to blinding mangrove-sundri mix. This progressive shift in habitat preference is not only visible in terms of tree species selection for nesting, but also in their overall breeding distribution, which suggests a changing preference toward freshwater areas upstream.

We do not have data from this preliminary study to understand why shifts in Masked Finfoot nest location and nest-site variables occurred. However, there are several possibilities that we outline here that require specific assessment. The difference in nesting habitat preference could be attributed to an increasing level of salinity

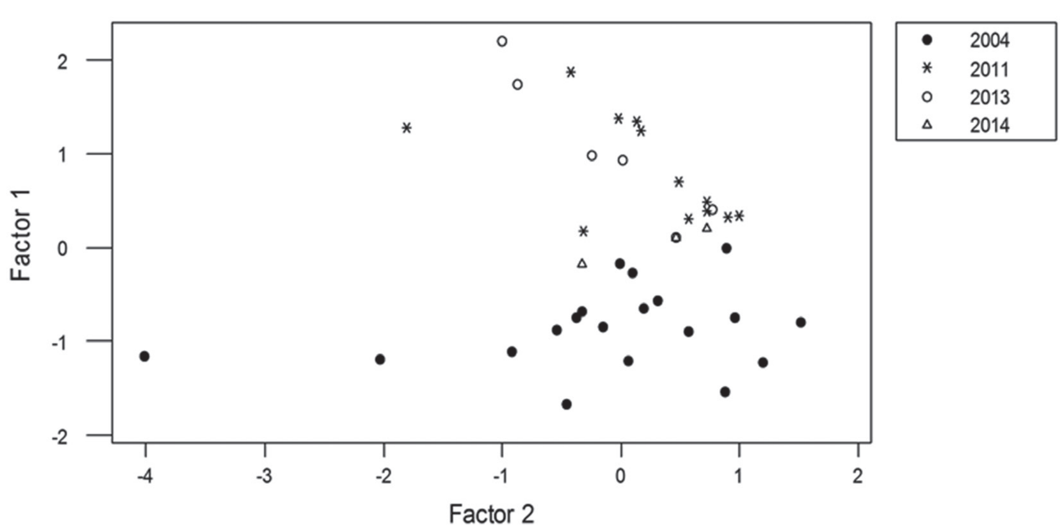

Figure 2. Factors 1 and 2 coded by year indicating the year 2004 was distinct from other years in relation to nest site characteristics.

Table 2. Loadings of each variable against Factors 1, 2 and 3 along with associated communality values.

Variable	Factor 1	Factor 2	Factor 3	Communality
Tree species	-0.386	0.109	-0.840	0.867
Nesting height	-0.483	0.537	0.108	0.533
Tree diameter	-0.589	-0.542	0.286	0.722
Nest stream diameter	-0.433	-0.486	0.123	0.439
Creek width	0.690	0.210	-0.119	0.534

in Kotka and Kochali areas along the coast (where most of the 2004 nests were located). There is mounting evidence that sea level rise (Islam and Gnauck 2011; Aziz *et al.* 2013) and upstream water extraction or divergence (Islam and Gnauck 2011; Aziz *et al.* 2013) have been affecting vegetation composition (Chowdhury *et al.* 2016; Sarker *et al.* 2016). Furthermore, high mortality and post-2004 habitat destruction (Ahmed *et al.* 2011) due to tropical cyclone (e.g., Sidr) led to reduced number of suitable nesting trees, especially sundri, and these factors possibly also affected the density of prey species, such as crab, that are important for Masked Finfoots (Neumann-Denzau *et al.* 2008).

Wahid *et al.* (2007) measured water salinity at the Supati and Katka measuring stations between November 2001 and October 2002; at Supati the salinity level was more than 5 ppt on only 83 days, whereas at Katka (southeast coast of the Sundarbans) the salinity level exceeded 10 ppt for more than 246 days. Overall, this indicates that the salinity level is higher in areas along the coast (e.g., Kotka, Kochikahli) of the eastern Sundarbans than further upstream (e.g., Supati). This suggests that the salinity level increased further (due to reduced freshwater supply) in the nesting sites closer to the coast since 2004 (Sarker *et al.* 2016), possibly forcing the Masked Finfoot to move to less saline areas upstream where higher density of preferred nesting trees occur. However, since the 2004 surveys (Neumann-Denzau *et al.* 2008) only covered part of the upstream areas (Fig. 3), we cannot decisively arrive at any conclusion (but see Sarker *et al.* 2016).

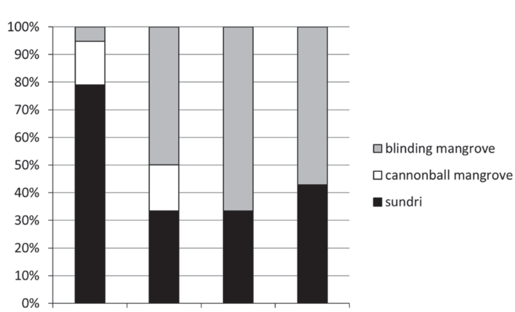

Figure 3. Change in tree species used for nesting by Masked Finfoots observed in different years in the Sundarbans.

Cyclone Sidr, with heavy rain, wind (22 kmph) and tidal surge (3-4 m), hit the Sundarbans as a Category 4 cyclone on 15 November 2007 and largely affected the southeastern (Katka-Kochikhali area) part of the Bangladesh Sundarbans (Mallick and Vogt 2009; Cornforth *et al.* 2013). Bhowmik and Cabral (2013) found that both sundri and blinding mangrove were largely affected by the cyclone. After 2007, Masked Finfoots were not recorded in the Katka-Kochikhali area despite regular visits by tour guides until 2012 (M. A. A. Diyan, pers. commun.) when an adult male was observed. Lack of records and evidence of severe physical destruction by Cyclone Sidr in 2007 indicate that there has been a decline in the Masked Finfoot population in the area due to the high mortality of birds and habitat destruction.

We found that nests were located in creeks of a larger width in 2004 compared to other years (Fig. 3). Heavier sediment deposition has caused many of the creeks to become smaller and narrower (Sarker *et al.* 2016). It is possible that Masked Finfoots are nesting in environments that barely fulfill their requirements switching to narrower creeks and less preferred trees for nesting. Our findings suggest a sharp decline of the Masked Finfoot in the coastal sites of the Sundarbans concomitant with a northward

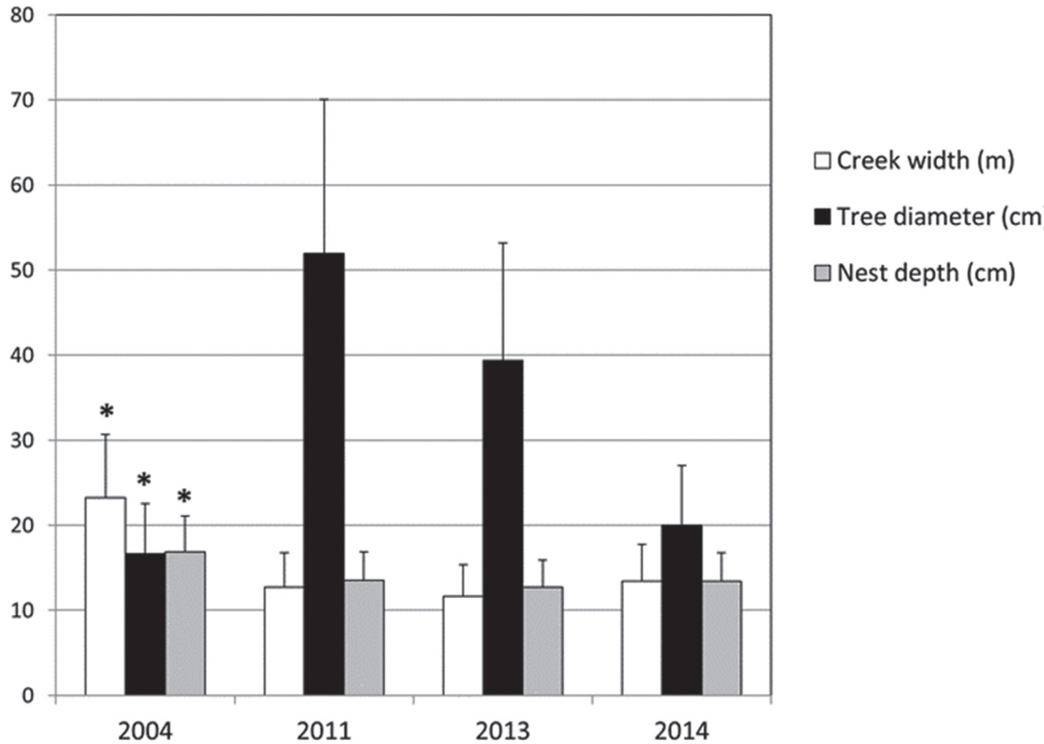

Figure 4. Variation in selected nest or nest site characteristics of Masked Finfoots in the Sundarbans in relation to year (significant at $\alpha = 0.05$).

shift in nesting habitat. Therefore, to fully understand the reasons causing this decline in population or shift in nesting areas, we recommend a long-term study on the nesting ecology of the Masked Finfoot in the Sundarbans of Bangladesh covering greater areas and multiple sites and collecting additional habitat-associated data such as salinity, vegetation composition and food availability.

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