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continued on the back inside cover

**Cover: Himalayan Gray Langur *Semnopithecus ajax* (adult female) © Rupali Thakur.**

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COMMUNICATION

# A comparison of the breeding biology of White-throated Kingfisher *Halcyon smyrnensis* Linnaeus, 1758 in plains and hilly areas of Bangladesh

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**Abstract:** The breeding biology of White-throated Kingfisher *Halcyon smyrnensis* was studied in plains and hilly areas from September 2008 to August 2011. Four villages under Savar upazilla were selected for plains, and Chittagong University Campus, Chattagram for the hilly area. The breeding season started in February in hills and April on plain. Mean (SD) time required to build a new nest was 11.3 (3.9) days in plains and 15.3 (0.57) days in hills. Clutch size was 3–4 in hills and 3–7 in plains. Mean egg parameters (length, width, and weight) and mean egg volume and surface area were similar in both areas. The mean incubation period on plains was 16.4 (1.2) days, in hills 14.1 (0.7) days. On plains fledging success was 52%, compared to 57% in hills. Theft by local inhabitants was a major reason for fledgling loss in plains, hence increased public awareness may reduce nestling mortality and increase breeding success.

**Keywords:** Breeding season, breeding success, fledglings, hatchling, nest, nestling mortality, ornithology.

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**Author contributions:** NJS has played a crucial role in monitoring and guiding the work. SIK has carried out field survey, data collection and HN also executed field study, data analysis and documentation.

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## INTRODUCTION

The Least Concern, common, resident and widely distributed White-throated Kingfisher *Halcyon smyrnensis* Linnaeus, 1758 inhabits different types of habitats and water bodies (IUCN 2015) throughout Bangladesh. It feeds on fish, arthropods, amphibians, and reptiles (Naher & Sarker 2014) and prefers to nest in sandy-loam steep hills/mounds near or far from water bodies (Naher & Sarker 2016). The high porosity of sandy soils provides better ventilation, which is important to diffuse gases to maintain a tolerable level of $O_2$ and $CO_2$ in the nest cavities (White et al. 1978). Studies are available on the feeding behavior and breeding biology of White-throated Kingfisher in India (Yahya & Yasmin 1991; Balasubramanian 1992; Oomen & Andrews 1996, 1998; Asokan et al. 2009, 2010; Palkar et al. 2009). In Bangladesh, several studies have been done on feeding behavior (Naher & Sarker 2015a,b, 2016, 2018), but information on breeding is limited. As wetland habitats are rapidly declining and water pollution is increasing alarmingly, it is important to determine the breeding biology of this species to make a conservation plan. This study aimed to establish a morphometric analysis of eggs, hatchlings and fledglings, breeding success, and the causes of eggs and hatchling loss.

## MATERIAL AND METHODS

### Study area

The study was carried out from September 2008 to August 2011. The study was done in Madhabchala (23.886 °N & 90.253 °E), Boro-Walia (23.886 °N & 90.251 °E), Sinduria (23.883 °N & 90.236 °E), and Kashipur (23.884 °N & 90.242 °E) villages under Savar Upazilla in Dhaka district, west of the Jahangirnagar University Campus (Image 1). These villages are situated on plain land (4–7 m). At the backyard of most of the houses of these villages, people dig holes to dump their daily household wastages. At the vertical site of these holes (1–3 m deep from the ground), the kingfishers built their nests. They nested on the vertical side of the mound, which was newly cut down for other purposes. One nest was built at Madhabchala and one in Boro-Walia in 2009, which were reused in 2010. One nest was built at Kashipur in 2010 and one at Sinduria in 2011. Three nests were recorded in Chittagong University Campus (CUC) (22.281 °N & 91.472 °E) (Image 1) in Chattagram. The CUC is located at the village Fatehpur under Hathazari Upazila of Chattagram District. The CUC stretches over an area of 7 km² which is dominated by hills, valleys, creeks, streams, lakes, crop fields, grass, and fallow lands (Kabir et al. 2017). Seventy-two percent of the campus area is hilly and comprises of small hills which are 15–90 m high (Islam et al. 1979) and the remaining areas are either plains or valleys (Islam et al. 1979). Hills and plains are ornamented with hilly streams (Kabir et al. 2017) and some creeks (Islam et al. 1979). The mixed-evergreen vegetation (Champion 1936) of this area is now converted into secondary growth (Ahsan & Khanom 2005) due to anthropogenic factors (Kabir et al. 2017). About 665 plants species have been reported in CUC (Alam & Pasha 1999). The major habitats for the birds in the CUC are: Katapahar, botanical garden, south campus, Vice Chancellor's Hill, and north side of the Shaheed Abdur Rab Hall (Image 1). Residential area for students and faculty building are located on hills of CUC. Hills are connected with different roads (Image 1). Two nests were built on Vice Chancellor's Hill and another nest was built on Katapahar.

### Methods

Courtship and pair formation behavior was observed on plains only, and involved key elements: (i) advertising display**:** one bird squatting on a tree branch, calling and jerking its head right and left and flying from one branch to another around the other bird, (ii) head bobbing: squatting on a tree branch, head jerking up and down while neck and nape drew back and almost or actually touched the back, (iii) mutual display: one bird displayed, and the other joined with and did the same while both birds sat side by side on the same or different branches (0.05–2 m, median = 1.5 m, no. of observations = 42), (iv) courtship flight: while the receiver sat beside the advertiser and calling one by one, in between calling the synchronized flight occurred while the pair called harshly together, 'Crack…crack…crack…crack', (v) courtship feeding: one bird offered fish to other and the other bird held the fish at the tail first and then swallowed turned to the head first, sometimes engulfed or gave it back to first bird and it engulfed while the pair spent some time through this behaviour, and (vi) mounting: while one bird mounted over another with or without cloaca contact.

Incubation period: Focal animal sampling (Altman 1974) at 5-minute intervals was recorded for incubation on different days subdivided into four time periods: 0700–1000 h (morning), 1001–1300 h (late morning), 1301–1600 (afternoon), and 1601–1900 h (evening). Two nests were followed for these activities on plains to find out the percentage of time spent in incubation at

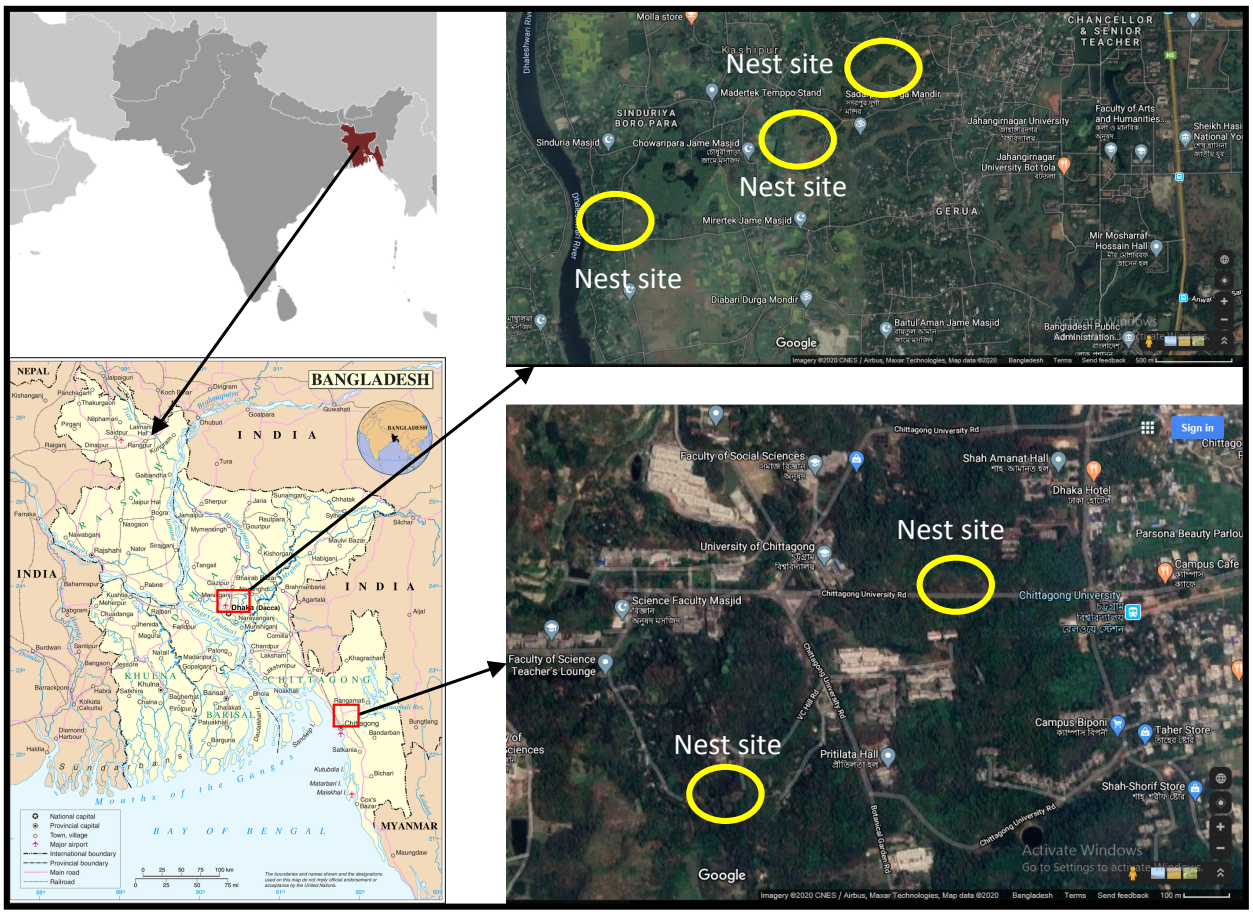


**Image 1. Study area.**

different day periods.

Egg measurement: Each egg was marked as I, II, III, and so on with permanent ink and measured with slide calipers and weighed to the nearest 0.5 g with a digital pan balance.

Egg volume and egg surface area were calculated using the following formula (Narushin 2005; Muzaffar et al. 2012):

Egg volume = $(0.6057–0.0018B) LB^2$

Where L = maximum length in mm and B = maximum breadth in mm.

Egg surface area, S, was calculated as S = (3.155 - 0.0136L + 0.0115B) LB, in which both L and B are taken in millimeters.

The breeding success was calculated by using the following formulae:

Hatching success (%) = (No. of eggs hatched / total no. of eggs laid) x 100

Fledging success (%) = (No. of nestlings fledged / total no. of nestlings hatched) x 100

Breeding success (%) = (No. of eggs laid / No. of nestlings fledged) x 100

## RESULTS

### Breeding season

The breeding season was February to July in hilly area and April to August in plain land. Pair formation occurred through a course of displaying behavior. At first, one bird started its advertising display to attract other bird, by squatting on bamboo, electric wire or any other support over the water which continued for 7–10 days (avg. 8.4 ± 1.3, n = 10). This behavior was followed by head bobbing which occurred 8–17 times per minute (mean 13.8 ± 3.2, n = 10). Head bobbing was followed by courtship flight which was recorded for 1–3 days (mean 1.8 ± 1, n = 6) through which pair formation occurred permanently. It involved chasing each other with calling and one bird caught fish and offered to another in between courtship flight. Mounting took place after permanent pair formation which lasted 1–3 seconds when cloaca contact did not occur, but extended up to 3–7 sec (4.5 ± 1, n = 12) while cloaca contact occurred. During mounting both birds flapped their wings and

called. After mating, they flew away from each other towards the nearby branches and preened their feathers for 1–5 minutes (median 4.2, n = 12).

**Nest**

After pair formation, both the birds selected an abandoned, isolated and $90^0$ sloppy sandy-loam area near or away from human habitation. In plains (Savar), they built their nests at the vertical edge of the ditch or pond or mound near human habitation. In hills (CUC), they built their nests near the top of the hill. They built more than 80% (81.9 ± 6.7%) false nests (1–5, 5.2 ± 2.3, n = 5) on either side of the true nest (Image 2, 3) in plains but below 30% (27.8 ± 48.1%) in hills (5 false nests in case of one true nest and other two had no false nests) which did not lead to any egg chamber but the true nests ended in a widened egg chamber. The nests were excavated at 30–118 (46.7 ± 143.31, n = 12) cm down from the hill or mound top and 10.5–483 cm (122.7cm ± 143.31, n = 12) height from the ground or above water. The nest was built at a higher height and larger horizontal length on hills than on plains (Figure 1). They followed almost the same distance down from the top of the hills, hillocks or mounds (Figure 1). The horizontal and vertical diameter (dm) of both entrance (outer opening) and egg chamber was larger in true nests in all sites (Figure 2). In the plains, they built their nests at 30–94 cm down (67.7 ± 25.3, n = 7) from the top of the mound/highland and 10.5–97 cm height from the ground. But in hills, they preferred to nest at 48–126 cm down from the top hill and 31–1,524 cm height from the base of the hills (673.7 ± 767.9, n = 3).

To build a new nest, less time was required in plains (8–17 days, 11.3 ± 3.9 days) than hills (15–16 days, 15.33 ± 0.57 days) whereas in plains it required 8–12 days to reconstruct the old nest (10.2 ± 1.8), but in hills no old nests were found to be used.

**Egg laying**

The eggs were laid during April in hills and May–June in plains. They laid eggs on successive days (78.4%, n = 24), one-day interval (8.1%) but two eggs were also laid in one day (13.5%) (Table 1).

**Clutch size**

The clutch size varied from 3–7 eggs (mean of 4.6 ± 1.3, n = 7). The clutch size was smaller (3–4; 3.5 ± 0.7, n = 2) in hills than plains (3–7; 5 ± 1.2, n = 30).

**Colour, shape and morphometry of the eggs**

The colour of the egg was white and they were almost round in shape (Image 4). Overall, the length of the eggs varied from 2.7–3.03 cm (2.9 ± 0.09 cm, n = 37), the width 2.4–2.7 cm (2.6 ± 0.07 cm, n = 37) and the weight 7.8–10.8 g (10.04 ± 0.7, n = 37) (Table 2). The length is significantly correlated with width (0.39, df = 35, p >0.05) and weight (0.38, df = 34, p >0.05), and width is also significantly correlated with weight (0.80, df = 35, p >0.05).

In plains, the average length (range 2.7–3.03, mean 2.87 ± 0.09 cm, n = 30) was slightly larger than the hills (length: range, 2.81–3.1 cm, mean 2.93 ± 0.09 cm, n = 7) but the mean weight was (range 7.8–10.8 g, mean 10.09 ± 0.6 g, n = 30) slightly heavier than the hills; (weight: range, 8.5–10.5 g, mean 9.8 ± 0.7 g, n = 7), the mean width was similar in hills (range, 2.5–2.7 cm, mean 2.6 ± 0.07 cm, n = 7), and plains (range, 2.4–2.7 cm, mean 2.6 ± 0.06 cm, n = 30).

**Table 1. Nesting detail of White-throated Kingfisher in different sites.**

| NS | Year | Egg laying dates | | | | | | | Egg hating dates | | | | | | | Fledging dates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| M | 2009 | 14/6 | 15/6 | 15/6 | 16/6 | 17/6 | 18/6 | | 28/6 | 28/6 | 28/6 | 29/6 | 4/7 | 2/7 | 3/7 | Stolen |
| B | 2009 | 3/7 | 4/7 | 5/7 | 7/7 | 8/7 | | | 19/7 | 20/7 | UH | 21/7 | UH | | | 13/8 |
| C | 2009 | 12/4 | 14/4 | 15/4- | - | - | | | 28/4 | 30/4 | 1/5 | | | | | Died |
| M | 2010 | 8/4 | 10/4 | 10/4 | 11/4 | 12/4 | | | 25/4 | 25/4 | 27/4 | 27/4 | 27/4 | | | 20/5 |
| B | 2010 | 12/5 | 13/5 | 13/5 | - | - | | | UH | UH | UH | | | | | UH |
| C | 2010 | 22/4 | 23/4 | 23/4 | 24/4 | - | | | 6/5 | 6/5 | 6/5 | 7/5 | | | | 26/5 |
| K | 2011 | 2/5 | 3/5 | 4/5 | 5/5 | 6/5 | | | 18/5 | 19/5 | 21/5 | 20/5 | 20/5 | | | 13/5 |
| S | 2011 | 20/5 | 22/5 | 22/5 | 23/5 | 24/5 | | | 7/6 | 7/6 | 7/6 | 7/6 | 10/6 | | | Stolen |

M—Madhabchala | B—Barawalia | C—Chittagong University Campus, Chattagram | S—Shinduria | K—Kashipur | UH—Unhatched.

**Table 2. Egg measurement of White-throated Kingfisher in different locations.**

| Yr | SA | Egg measurement (cm) | | | | | | | | | | | | | | | | avg± SD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st egg | | | 2nd egg | | | 3rd egg | | | 4th egg | | | 5th egg | | | 6th egg | | | 7th egg | | | | |
| | | L (cm) | W (cm) | Wt. (g) | L (cm) | W (cm) | Wt. (g) | L (cm) | W (cm) | Wt. (g) | L (cm) | W (cm) | Wt. (g) | L (cm) | W (cm) | Wt. (g) | L (cm) | W (cm) | Wt. (g) | L (cm) | W (cm) | Wt. (g) | L | W | Wt. |
| 2009 | M | 2.91 | 2.65 | 10.5 | 2.95 | 2.69 | 10.4 | 2.87 | 2.61 | 10.6 | 2.98 | 2.63 | 10.5 | 2.81 | 2.58 | 10.3 | 2.7 | 2.62 | 10.1 | 2.79 | 2.68 | 10.1 | 2.9±0.09 cm | 2.6±0.07 cm | 10.04±0.7 g |
| | B | 2.97 | 2.6 | 10 | 2.9 | 2.64 | 10.3 | 2.84 | 2.67 | 10.3 | 2.88 | 2.6 | 10.1 | 2.86 | 2.67 | 9.9 | | | | | | | | | |
| | C | 2.81 | 2.59 | 10.2 | 2.9 | 2.7 | 10.3 | 2.94 | 2.6 | 9.9 | | | | | | | | | | | | | | | |
| 2010 | M | 2.94 | 2.63 | 10.5 | 2.89 | 2.67 | 10.3 | 3.03 | 2.63 | 10.4 | 2.92 | 2.59 | 9.9 | 2.86 | 2.59 | 10.2 | - | - | - | - | - | - | | | |
| | B | 2.83 | 2.52 | 7.8 | 2.8 | 2.4 | 7.9 | 2.81 | 2.53 | 9.4 | - | - | - | - | - | - | - | - | - | - | - | - | | | |
| | C | 2.9 | 2.6 | 9.2 | 2.9 | 2.5 | 8.5 | 3.0 | 2.7 | 10.3 | 3.1 | 2.7 | 10.5 | - | - | - | - | - | - | - | - | - | | | |
| 2011 | K | 3.01 | 2.7 | 10.6 | 2.98 | 2.68 | 10.7 | 2.9 | 2.6 | 10.1 | 2.85 | 2.68 | 10.2 | 2.97 | 2.6 | 10.8 | | | | | | | | | |
| | S | S2.7 | 2.6 | 10.2 | 2.8 | 2.61 | 10.0 | 3.0 | 2.58 | 10.5 | 2.72 | 2.69 | 9.5 | 2.76 | 2.69 | 10.6 | - | - | - | - | - | - | | | |

M—Madhabchala | B—Barawalia | C—Chittagong University Campus, Chattagram | S—Shinduria | K—Kashipur | UH—Unhatched | L—Length | W—Width | Wt.—Weight.

### Egg volume and surface area

The egg volume (EV) and the surface area (ES) were almost similar both in hills (EV: 10.8 $cm^3$, ES: 22.9 $cm^2$) and plains (EV: 11 $cm^3$, ES: 23.1 $cm^2$).

### Incubation

Both the partners took part in incubation. After laying the first egg, the parents started to incubate it. If one bird incubated, the other stayed outside the nest. They continuously incubated for 2–40 min (19.3 min ± 9.5, n = 30) with taking 2–20 min (11.2 min ± 8.6, n = 30) rest and repeatedly did the same. As one bird rested, another one entered in between 10–180 sec (74.6 sec ± 49.3, n = 30). After 10 days, one of the parents left the nest. After that, only one bird incubated the egg. Time spent in incubation was found to increase as the days of incubation proceeded (Figure 3) and but this relation was not significantly correlated (r = 0.9, df = 4, P >0.05). Spending time in incubation also varied according to day periods (Figure 4).

### Incubation period

The incubation period ranged from 13–18 days (15.9 ± 1.5 days, n = 37), in plains it was larger (14–18 days, 16.4 ± 1.2 days, n = 30) than hills, (13–15 days, 14.1 ± 0.7 days, n = 7), 15–17 days was the most common (65.7%) followed by 16 days (16.2%), 18 days (13.5%), 14 days (13.5%) and 13 days (2.7%). Different clutches of different nests had different incubation period and the test was statistically significant (r = 0.53, df = 6, P <0.05).

### Hatching

One (66.7%) to four (4.8%) eggs was hatched in one day. The parent started to collect food for hatchlings and fed their nestlings immediately after the first egg hatched out. The parents repeatedly collected food with an interval of 1–20 min (8.7 min ± 6.3, n = 35).

### Hatching success

Overall, a good number of eggs (13.5%) were destroyed due to infertility (n = 37). But it occurred only in plains (13.7%, n = 30) and no egg was reported damaged in the hills. Altogether, the hatching success was 85%. It was higher in hills (100%) than plains (83.3%). than hills (3.5 nestlings).

### Physical features of the hatchling

The newly hatched hatchling was naked with transparent body skin and flesh colored (Image 5). The beak and claws were black. Their eyes were closed. Eyelids appeared large and dark gray. Egg tooth was

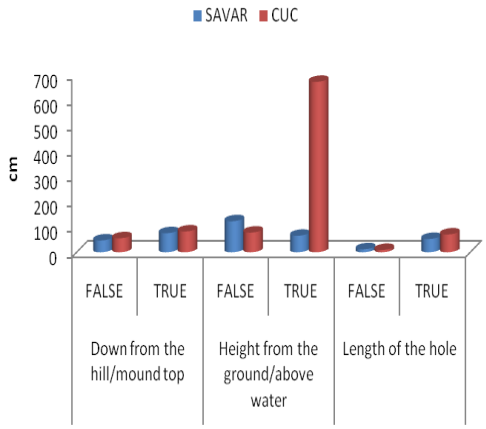


Figure 1. Measurement of location and horizontal length of false and true nests.

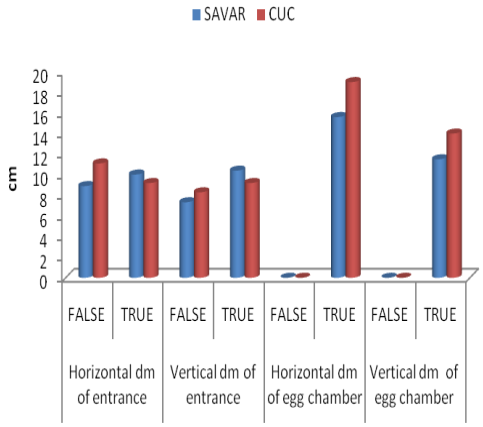


Figure 2. Measurement of outer opening and egg chamber of false and true nests.

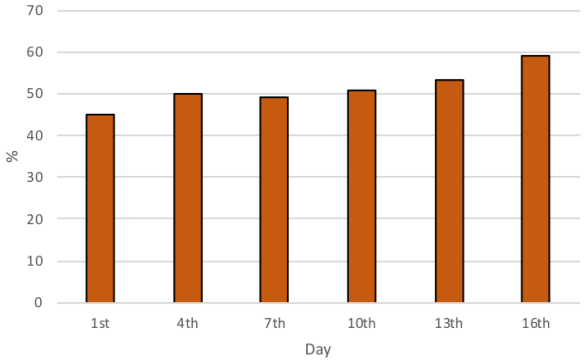


Figure 3. Incubation period at different day.

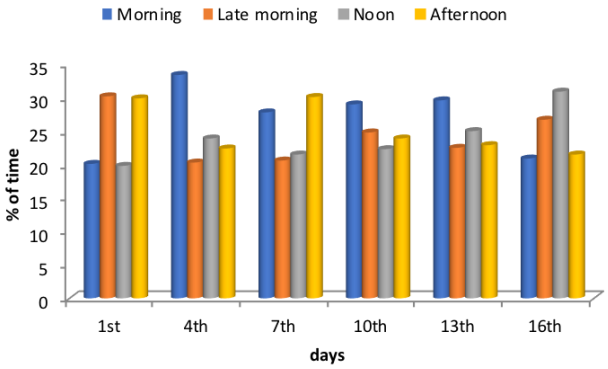


Figure 4. Incubation period at day periods at different days.

Table 3. Measurement of different body parts of the hatchling and fledgling with reference

| Var | Hatching at the Catching time, range (meant sd) | | Fledgling at the fledging time, Range (mean ± sd) | | Adult (ADW 2020) |
|---|---|---|---|---|---|
| | Plains (SAVAR) (n = 20) | Hills (CUC) (n = 7 | Plains (SAVAR) (n = 13) | Hills (CUC) (n = 4) | |
| BW (g) | 12.5–16.5 (14.9 ± 1) | 12–15.9 (14.5 ± 1.3 | 63.3–73.9 (69.5 ± 3.2 | 68.9–73.3 (71.5 ± 1.9) | 65.5-81g |
| BL (mm) | 50–69 (61.4 ± 5) | 60–67 (63.5 ± 3.1) | 185–230 (207.1 ± 4.1) | 182–203 (192 ±10.1) | 194 to 210 |
| WL (mm) | 14.1–26 (19.9 ± 4) | 15–26 (21.8 ± 5.3) | 108–121 (112.1 ± 3.1) | 110–113.2 (111.8 ± 1.5) | |
| HL (mm) | 8.1–15 (11.3 ± 2.1) | 10.3–18 (13.9 ± 3.2) | 29.1–33.7 (30.7 ± 1.4) | 30–30.4 (30.1 ± 0.2) | |
| BeL (mm) | 2–4.5 (3.1 ± 0.9) | 2.4–5.2 (4.2 ± 1.3) | 39.9–42.5 (40.7 ± 0.7) | 36.7–42.3 (39.4 ± 2.3) | |
| FL (mm) | 16.3–19.5 (17.7 ± 1) | 18.3–19.8 (19.2 ± 0.7) | 28.3–30.7 (29.6 ± 0.7) | 30.1–0.1 (30 ± 30.2) | |
| TL (mm) | 8–9.8 (8.9 ± 0.5) | 9–9.9 (9.3 ± 0.4) | 14.6–15.8 (15 ± 0.4) | 14.4–15.5 (15 ± 0. 5) | |
| CL (mm) | - | | 4.6–5.6 (5.1 ± 4.6) | 5.1–5.3 (5.3 ± 0. 1) | |
| PL(mm) | - | | 57.1–74.6 (66.8 ± 5.7) | 68.4–73.1 (71 ± 2.4) | |
| RL(mm) | - | | 19.1–32.1 (27.5 ± 3.7) | 25.1–31.2 (28.3 ± 2.6) | |

Var—Variables | BW—Body weight | BL—Body length | WL—Wing length | HL—Head length | BeL—Beak length | FL—Feet length | TL—Tarsus length | CL—Claw length | PL—Primaries length | RL—Rectrices length.


Image 2. Nest of White-throated Kingfisher in Savar.


Image 3. Nest of White-throated Kingfisher in CUC.


Image 4. Clutch of White-throated Kingfisher.

present which disappeared at the 9th–10th day of hatching. The claw, wing and tail feathers were absent. The eyes were closed which were beginning to open on the 5th–7th days and fully opened at 9th–10th days after hatching.


Image 5. Physical feature of the hatchlings of White-throated Kingfisher.


Image 6. Physical feature of the nestling of White-throated Kingfisher.

The hatchlings were measured on the day of hatching (Table 3). The body weight and length of different body parts reached very close to an adult at the time of fledging. Physical features of the fledglings' were similar to adults except of size (Image 6).

**Fledging period**

Overall, the fledging periods ranged from 23–26 days (24.3 days ± 1) both in plains and hills. Most (35.3%) of the hatchlings were fledged after almost a similar number of days (24 days).

**Fledging success**

In total, the fledging success was 53.1% (n = 32). It was lower (52%) in plains than hills (57.1%). Overall, stealing (37.5%) and natural death (9.4%) were the causes of fledgling loss. In plains, 48% fledgling were lost due to steal by local boys and in hills 42.9% fledgling were lost due to natural death. Food shortage and starvation may be the reason in hills as reduced food resource facilities were recorded as mentioned earlier.

**Breeding success**

The breeding success was 53.1% in relation to eggs hatched (n = 32) and 45.9% in relation to eggs laid (n = 37) but it was lower (52%, n = 25, in relation to eggs hatched and 43.3%, n = 30, in relation to eggs laid) in plains than hills (57.1% in both eggs hatched and laid, n = 7). Only 2.1 nestlings were able to fly per nest overall. In plains it was better (2.2 nestlings per nest) than in hills (2 nestlings per nest).

**Mortality rate**

Overall, the mortality rate was 46.9% in relation to eggs hatched (n = 32) and 54.1% in relation to eggs laid (n = 37). It was higher in plains (16.7%) than hills (0%) both with eggs laid and to eggs hatched (48% and 42.9%, respectively). The mortality rate before hatching was less (13.5%) but after hatching it was highly increased (40.1%).

## DISCUSSION

The breeding season started a little bit earlier in hilly areas than in plain lands. Most of the observers around the world found the breeding season was more or less the same as found in the present study (Whistler 1986; Ali & Ripley 1987; Grimmett et al. 1998; Govindarajalu 2008). Pair formation occurred via a course of courtship display involved head bobbing and courtship flight. Ali & Ripley (1987) and Anderton & Rassmussen (2005) observed advertising display of White-throated Kingfisher in India. Courtship flight was approached to permanent pair formation by offering food to each other. Such courtship feeding was reported during nest excavation of White-throated Kingfisher (Palker et al. 2009) and before fertilization in Pied Kingfisher *Ceryle rudis* (Cramp et al. 1988) which prepares the female to reproduce by providing her with more resources (Cramp et al. 1988). Courtship feeding led to mounting which occurred with or without cloacal contact. In between performing sexual activities, both the partners selected an abandoned place for nesting and started nest excavation. They built several false nests without egg chambers on each side of the true nest to avoid predator risk. More false nests were built in plains than hills as predator risk was high on plains. To protect eggs, the pied kingfisher built 80% false nests which had no egg chambers (Cramp et al. 1988). The nest height from the ground depends on the height of selected mounds or hills, they are excavated at the highest height. Higher height was observed in hills than in plains. Palker et al. (2009) reported the nest was excavated in a vertical bank 150 cm high from the ground. This height was higher than the present study on plains but lower than in the hills as the height of the nesting site varied from place to place. The nest contained longer horizontal lengths in hills than on plains. Nest building time was more on excavating a new nest than rebuilding an old nest which was also recorded in other species (Naher & Sarker 2016). Palker et al. (2009) observed pairs occupying the same area for 3–4 years. They suggested only ringing will confirm the reuse of a nest or site by the same pair. The mean length of the nest hole in hills (70.3 ± 14.3 cm) is similar (69.00 ± 4.74 cm) to the findings of Govindarajalu (2008) in India. The length of the nest hole in hills was larger than in plains (52.6 ± 18.5 cm). One meter-long horizontal tunnel-like nest ends excavated in a vertical cutting of earth on the bank of a river, stream, nullah or a roadside land cutting (Palker et al. 2009). The circumference of the nest entrance hole opening was 8.64 ± 0.73 cm in India (Govindarajalu 2008). The depth of the egg chamber of the true nest in plains (11.5 ± 1.04 cm) was almost similar to the findings (10.47 ± 1.86 cm) of Govindarajalu (2008) but larger (14 ± 2 cm) in hills. Both the parents shared in building or reconstructing the tunnel-like nest which was also reported by others (Palker et al. 2009; Naher & Sarker 2016). However, the White-throated Kingfisher is known to use various locations for constructing its nest (Balasubramanian 1992; Palker et al. 2009).

The egg laying period in the hills of the present study (in late March to early April) was a little bit later (May–June) in the plains. One to two days intervals were recorded in egg laying time which was similar to Palker et al. (2009) reports (24–48 h) but two eggs were laid in the same day was also observed in the present study. A larger clutch size was recorded in plains than in hills. Smaller clutch size (3–5 eggs, 3.7 ± 0.82) was recorded by Whistler (1986), Ali & Ripley (1987), and Singer (1996). Larger clutch size was recorded by Palker et al. (2009) (4–7 eggs, usually 5–6 eggs) and Govindarajalu (2008) (4 eggs). Clutches of five eggs were common in plains. Reduced clutch size in hills may be due to less food source around the nest as the site was far from agricultural lands, grooves, ponds, paddy fields, electric lines, shrubs, and trees. But on plains, they built their nests close to agricultural lands, grooves, ponds, paddy fields, electric lines, shrubs, and trees from which the parents get more opportunity to provide foods to the growing nestlings. The agricultural lands and groves provided a variety of protein rich insects and other prey for the growing nestlings as well as for the parents

(Naher & Sarker 2016). The nearest small trees, shrubs, sticks and electric lines served as a perching site for overseeing the nest and searching for prey (Asokan et al. 2010; Naher & Sarker 2016). Moreover, in hills they preferred to nest at the site where predator pressure (such as local boys, snake, and monitor lizard) was less. This factor may be responsible for larger clutch size in plains. The condition of the breeding female, availability of resources necessary to produce eggs, time of laying in the season and anticipated future availability of food for feeding nestlings may influence the variability of clutch size (Klomp 1970; O'Connor 1984; Lessels & Krebs 1989). The round-shape and white colour eggs are similar to other studies in different regions (Whistler 1986; Ali & Ripley 1987; Singer 1996; Palker et al. 2009) but spherical (Whistler 1986), spherical oval (Ali & Ripley 1987; Palker et al. 2009) shaped eggs were also reported in India. The measurement of the length and breadth of the eggs has more or less coincided with other findings (Whistler 1986). Similar sized eggs were found both in plains and hills. Govindarajalu (2008) found almost similar sized (2.9 ± 0.13 cm, width of 2.7 ± 0.13 cm) but lower weight eggs (7.9 ± 0.83 g) in comparison to present study. The physical condition and nutritional status of the birds may vary from one place to another. Alternative incubation by parents occurred in both sites which were also reported by others (Ali & Ripley 1987; Singer 1996). Almost the same incubation period was recorded by different studies (Ali & Ripley 1987; Singer 1996) but Palker et al. (2009) and Oommen & Andrews (1993) reported a longer period (21–22 days and 18–21 days, respectively). Provisioning food sharing to the nestlings occurred by parents alternatively was reported by Naher & Sarker (2018) and Palker et al. (2009). Feeding by both parents commenced two hours after the first chick hatched (Palker et al. 2009). When both the parents brought food simultaneously, only one of them entered the nest while the other waited outside (Palker et al. 2009).

Hatching success was almost similar to the findings of Govindarajalu (2008) at Nagapattinam (80%) in India. Higher hatching success was found in hills but larger brood was recorded in plains. Reduce hatching success in plains was recorded due to infertility but Palker et al. (2009) reported infertility and black ants as the causes of egg loss. The eyes of the nestlings opened at the same age found in Pied Kingfisher (9 days) (Cramp et al. 1988). Naked and pink colour hatchlings of White-throated Kingfisher were also recorded by Palker et al. (2009) in India and Cramp et al. (1988) for Pied Kingfisher. More or less similar fledging period was found in different studies in the world (Singer 1996; Palker et al. 2009; 20–21 days). Fledging success was higher in Nagapattinam (82 ± 12.05%) in southern India (Govindarajalu 2008). Human disturbances and natural died were principle reasons to fledgling loss in the present study. Palker et al. (2009) recorded weaver ants, accidental drowning, caving in of the nest chamber and, falling out of nest hole are the causes of nestling loss and speeding vehicles to adult birds loss in Western Ghat of India. Breeding success was lower in the present study than in the studies in southern India (Govindarajalu 2008; 75%) and Western Ghats of India (77.3%; Palker et al. 2009). The mortality rate after hatching was higher in the present study which was similar to another study in Western Ghats (23.7%; Palker et al. 2009).

## CONCLUSION

Wetland degradation is the main threat to the White-throated Kingfisher as it lives in and around wetlands. Various anthropogenic factors are responsible to reduce their breeding success. Fish farmers used to trap them as they believed that they are a nuisance for fish farms. The use of insecticides and pesticides may affect their fertility as kingfishers built their nest beside paddy fields, fish farms, and agricultural fields. Local boys become a nuisance as they destroy the nests and nestlings just for fun. Public awareness is necessary to conserve this species. Conservation messages should be included in the textbook at the primary and secondary level to create awareness among students to prohibit the destruction of wild animals including their nests and nestlings. Inserting bamboo or stick or plantation of aquatic plants in between the crops in paddy fields and agricultural land may provide them with more food items like insects, fish or small snakes, amphibians, & tadpoles, the farmers can save money by reducing pesticides use in the crop field, and decrease water pollution.

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