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Full Length Research Paper

Observations on nesting ecology of White-breasted Kingfisher *Halcyon smyrnensis* (Aves: Coraciiformes) in Cauvery Delta, Southern India

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The nesting ecology of the White-breasted Kingfisher *Halcyon smyrnensis* was studied in Cauvery Delta of Tamil Nadu, Southern India between 2005 and 2006. A total of 46 nests were studied and the White- breasted Kingfishers were found to excavate long tunnels ranging in length from 48 - 152 cm (mean 114.1 ± 1.7 cm) and ending in widened egg chambers. The mean length and circumference of the nest entrance hole opening was 10.4 ± 0.2 and 27.9 ± 0.8 cm, respectively. They excavated nest holes at a mean height of 207.5 ± 15.2 cm from the bottom and 96.6 ± 3.2 cm from the top of sandy river banks. The clutch size varied from 3 - 5 with a mean of 3.7 ± 0.82 and clutches of three were very common. The egg dimensions (length x width) ranged between 37.5 x 25.3 mm and 28.4 x 21.6 mm. The weight of the eggs varied between 8.0 and 10.0 g (mean 8.9 ± 0.65 g). The mean incubation period of the white-breasted kingfisher was 15.3 ± 1.12 days. The newly hatched nestlings were 3.7 g in weight and reached a maximum of 70.5 g on day 24. A reduction in weight was noticed in the last few days and 61.8 g was recorded on day 27. The other body parts attained maximum maturity from hatching to fledging. The white-breasted kingfisher laid 88 eggs, of which 82 hatched (93%) and 66 flew out of the nest, making the fledging success 80%.

Key words: White-breasted Kingfisher, nest, eggs, nestling growth, breeding success.

INTRODUCTION

The White-breasted Kingfisher *Halcyon smyrnensis* (Linnaeus, 1758) is a common species found in plains and lower hills all over India, Pakistan, Sri Lanka, Myanmar, Bangladesh, Egypt and Iraq (Ali and Ripley, 1983). The adult has a bright blue back, wings and tail. Its head, shoulders, flanks and lower belly are chestnut, and the throat and breast are white. The large bill and legs are bright red. The flight of the white-breasted king-fisher is rapid and direct, the short rounded wings whirring. In flight, large white patches are visible on the blue and black wings. Sexes are similar, but juveniles are a duller version of the adult. Studies on the Indian king-fishers are scanty and are limited to casual observations and feeding behaviors (Sen, 1994; Mukherjee, 1975; Yahya and Yasmin, 1991; Oommen and Andrews, 1996; Srinivasalu, 2004; Asokan et al., 2009a). Except for these observations, nothing is known about the nesting ecology of white-breasted kingfisher in Southern India. Hence, the present study investigates the nesting ecology of the white-breasted kingfisher in Cauvery delta of Tamil Nadu, Southern India.

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MATERIALS AND METHODS

The study was conducted on the Cauvery river banks of Mannampandal (18°18'N and 79°50'E) in Nagapattinam District, Tamil Nadu, Southern India between 2005 and 2006. Agriculture is

Figure 1. A typical nest of White-breasted Kingfisher.

the major economy of this area, contributing a high share of rice production in the state. Sugarcane, groundnut, green gram, black gram, cotton, etc are other major crops cultivated in this area. The river Cauvery and its tributaries are the major perennial water sources used for irrigation. The predominant wood plant species found in the study area are *Cocos nucifera, Borassus flabellifer, Mangifera indica, Enterolobium saman, Tamarindus indicus, Ficus benghalensis, Acacia arabica,* and *Azadirachta indica.* Important shrub species are *Prosopis juliflora, Jatropha glandulifera, Adhathoda vesica.* Plantations of *Casuarina equisetifolia, Tectona grandis and Bambusa arundinacea* are also found in the study area. The north-east monsoon usually brings rain to the study area during October - December (65% of the total rainfall in a year); the dry season occurs between May and July.

During the breeding season, the study area was thoroughly searched to detect nests. The tunnel length, length and circumference of the entrance opening, distance of the hole to the bank bottom and distance of the hole to the bank top of each nest was measured by using a standard measuring tape and wooden scale (Asokan 1995). The tunnel depth was measured after the completion of breeding activities that is nest was broken at the end of the nesting period. A tunnel was slowly and carefully dug from one direction of the nest-site, to reach the egg chamber. After the egg measurements the egg chamber was closed with a dark steel plate for future use that is nestling measurements. The distance to the nearest agricultural lands, groves, human habitations, perch sites and electric lines were measured in meters with a marked rope.

The freshly laid eggs were numbered with a felt-tipped pen, measured with Vernier Calipers and weighed to the nearest 0.5 g with a spring balance and care was taken to avoid excessive disturbance, which might have attracted predators. The incubation period was determined from the first egg laid till the first egg hatched.

Growth changes in the White-breasted Kingfisher nestlings were measured using the method employed by Pettingil (1985). All the nests were visited every 3 days for taking morphometric measurements of the body parts. Disturbances were minimized by handling the nestlings very carefully during the measurements. All the nestlings were allotted individual identification marks. Totally six measurements were made *viz*., (i) body weight, using a spring balance of 1g accuracy; (ii) body length, from the tip of the bill to the tip of the longest rectrix; (iii) bill length, from the tip of the upper mandible to the base of the culmen; (iv) wing length, as the straight length from the bend of the wing to the tip of the longest primary; (v) tarsus length, measurement from the base of the tarsometatarsus to the base of the middle toe and (vi) tail length, the distance from the tip of the longest rectrix to the base of the middle rectrices.

The breeding success of the White-breasted Kingfisher 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

Nests

Breeding variables from 46 nests (26 active and 20 inactive nests) of the White-breasted Kingfisher were analyzed during the study period. The inactive or old nests were identified by their typical hole patterns and undigested prey remains such as fish, insects, lizards and amphibians found in the nest entrance hole and the egg chamber. They excavated a long horizontal narrow tunnel with widened egg chamber at the end. In the present investigation all the nests were observed on the side of sandy river banks (Figure 1). Total length of tunnel ranged between 48 and 152 cm with a mean of 114.1 ± 1.7cm. Mean length and circumference of nest hole entrance was 10.4 ± 0.2 and 27.9 ± 0.8 cm respectively. They excavated a nest with a mean height of 207.5 ± 15.2 cm from bottom and 96.6 ± 3.2 cm from top of the river banks. The surrounding micro-habitats such as agricultural lands, groves and perching sites were closer to the nests (Table 1).

Egg biology

Egg-laying starts late March and lasts until 6 April. Eggs were roundish oval in shape and possessed milky white color without any markings (Figure 2). Mean clutch size as observed in the nests of White-breasted Kingfisher was 3.7 ± 0.82 (range 3 - 5, n = 26). The mean length and width of egg was observed to be 34.8 ± 0.14 mm (n = 88) and 26.6 ± 0.32 mm (n = 88) respectively. The average egg weight was recorded to be 8.9 ± 0.65g (n = 88). The incubation period was around 14 - 17 days followed by the weaning period of 28 - 32 days (Table 2). The incubation started with the laying of first egg itself and second egg was laid roughly after an interval of 24 h; this was evident from the fact that chicks of different age group were seen in the same nest (Figure 3).

Nestling growth rate

First egg hatched on 16 April and egg hatching continued to late April, fledglings could fly and by early June (10 -15),

Table 1. Physical characteristics of White-breasted Kingfisher nests and habitat around the nests (n = 46).

Variables	Mean ± SD	Min.	Max.
Tunnel length (cm)	114.1 ± 1.7	48	152
Length of entrance hole opening (cm)	10.4 ± 0.2	06	15
Circumference of entrance hole opening (cm)	27.9 ± 0.8	16	29
Distance of hole to bank bottom (cm)	207.5 ± 15.2	38	440
Distance of hole to bank top (cm)	96.6 ± 3.2	55	106
Distance to nearest agricultural lands (m)	74.4 ± 3.7	35	125
Distance to nearest groves (m)	103.9 ± 5.9	40	200
Distance to nearest tree (m)	5.3 ± 0.5	0.5	15
Distance to nearest electric line (m)	7.1 ± 0.9	02	28
Distance to nearest human habitation (m)	460.6 ± 18.1	200	700

Figure 2. Eggs of White-breasted Kingfisher.

Table 2. Egg morphometry and reproductive success of the White-breasted Kingfisher.

	Length (mm)	Width (mm)	Weight (g)	Incubation period (days)	Brood size	Fledging rate
Mean	34.8	26.6	8.9	15.3	3.1	2.5
SD	0.82	0.32	0.65	1.12	0.61	0.43
Range	25.3 - 37.5	21.6 - 28.4	8.0 - 10.0	14-17	2 - 4	2 - 4

all young had departed the nests. The newly hatched nestlings were flesh colored and eyes closed. Eyelids appear large and dark gray. The egg tooth was visible near the tip of the upper mandible (Figure 3).

Nestlings grew from 3.7 ± 1.36 g at hatching to peak weight of 70.5 ± 5.63 g at day 24, then slowly declined and reached to the weight of 61.8 ± 3.05 g on day 27. The body length of nestlings reached from 3.7 ± 0.21 cm at hatching to 21.9 ± 0.16cm by the end of day 27. The bill length was 0.6 ± 0.14 cm at hatching and it reached to 4.5 ± 0.05 cm on day 27. The At the time of hatching, the length of wing was 1.4 ± 0.09 cm and it gradually increased and attained maximum length of 16.4 ± 0.10 cm on day 27. The tarsus length of the nestling was 0.6 ± 0.14 cm at hatching and attained the maximum size of 3.5 ± 0.04 cm. The tail length was 0.2 ± 0.05 cm at hatching and it increased to 4.3 ± 0.04 cm during day 27 (Table 3).

Breeding success

Of 88 eggs (from 26 nests) recorded during study period, 82 eggs hatched (93%) and 66 fledged (80%). Breeding

Figure 3. Newly hatched nestlings of White-breasted Kingfisher.

Table 3. Growth patterns of several body structures of White-breasted Kingfisher nestlings.

Age (Days)	No. of nestlings	Body weight (g)	Body length (cm)	Bill length (cm)	Wing length (cm)	Tarsus length (cm)	Tail length (cm)
0	64	3.7 ± 1.36	3.7 ± 0.21	0.6 ± 0.14	1.4 ± 0.09	0.6 ± 0.14	0.2 ± 0.05
3	60	4.9 ± 2.23	4.2 ± 0.88	0.7 ± 0.33	2.3 ± 0.07	0.9 ± 0.32	0.3 ± 0.07
6	58	12.4 ± 2.51	5.6 ± 1.02	1.4 ± 0.51	3.8 ± 0.28	1.4 ± 0.45	0.7 ± 0.21
9	58	26.3 ± 4.21	8.9 ± 0.94	1.9 ± 1.01	7.2 ± 0.64	2.1 ± 0.25	1.9 ± 0.40
12	58	32.4 ± 3.88	13.8 ± 1.55	2.6 ± 0.87	9.8 ± 0.21	2.5 ± 0.14	2.1 ± 0.33
15	55	41.4 ± 4.63	14.7 ± 1.21	3.1 ± 0.41	11.6 ± 0.48	2.7 ± 0.36	2.7 ± 0.61
18	51	58.6 ± 6.41	16.3 ± 0.99	3.6 ± 0.23	14.4 ± 1.01	2.8 ± 0.25	3.7 ± 0.21
21	40	67.4 ± 5.85	18.5 ± 1.33	4.1 ± 0.65	15.3 ± 0.68	3.2 ± 0.33	4.2 ± 0.05
24	46	70.5 ± 5.63	21.6 ± 0.14	4.3 ± 0.87	16.3 ± 0.25	3.3 ± 0.10	4.3 ± 0.08
27	30	61.8 ± 4.21	21.9 ± 0.16	4.5 ± 0.05	16.4 ± 0.10	3.5 ± 0.04	4.3 ± 0.04

success was 75%. The highest rate of breeding success observed in clutch size 3 (76%) and the lowest in clutch sizes 4 or 5 eggs (68%) . Mean brood and fledging per nest was 3.1 ± 0.61 and 2.5 ± 0.43, respectively (Table 2). The mortality rate before hatching was 0.86% and in nestling period was 25%.

DISCUSSION

In this study, 26 active nests of White-breasted Kingfisher were recorded in the Cauvery Delta region of Nagapattinam District, Tamil Nadu Southern India during 2005 - 2006. The White-breasted Kingfisher has a single brood from March - June. This is the same time as observed in Nagapattinam, Southern India by Madhuramozhi (2008). The availability of suitable food for nestlings is widely accepted as the main factor controlling the timing of avian breeding seasons (Lack, 1950; Thomson, 1950). In pre-sent study area, the ripening of paddy crops and sub-sequent preparation of the field for the next crop resulting in flushes of insects from March to July coincided with the breeding activities of the white-breasted kingfisher. Earlier, same time of breeding season in relation to food availability in some insectivorous birds were reported (Asokan et al., 2009 b,c, 2010). However, other factors such as temperature, rainfall, suitable nest-sites, and nest mates were also influenced the breeding season of the white-breasted kingfisher.

In the present study all the nests were located along the side of river banks. In some locations the white-breasted kingfisher was also used natural holes found inside the wells and under the bridge (personal observations). Earlier several researchers have proven that kingfishers, in general, preferred sandy river banks for nest construction

(Morgan and Glue, 1977; Brooks and Davis, 1987; Peris and Rodriguez, 1997; Heneberg, 2004; Madhuramozhi, 2008). Sandy soil preferences for nesting were also reported of other soil excavating avian species *viz*., Bee-eaters (Kristin, 1994; Burt, 2002; Heneberg and Simecek, 2004; Yuan et al., 2006; Asokan et al., 2010) and Sand Martin or Bank Swallow (John, 1991; Heneberg, 2001, 2003). Sandy soil provided number of advantages. Sandy soils have lower soil pressure, density and moisture than more clay- rich soils. Sandy soils probably provided faster and easier excavation of nest cavities. With high porosity, nest tun-nels constructed in sandy soils would also have 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) . Soil particle size could also affect the structure of the nest tunnels of the white-breasted kingfisher.

The white-breasted kingfisher excavated a tunnel from 48 - 152 cm with a mean length of 114.1 ± 1.7 cm. Ali and Ripley (1983) reported that the White-breasted Kingfisher build a nest tunnel of 1 - 2 m horizontally in an earth mound or sandy cutting or sides of a dry nullah. The nest entrance had a mean length of 10.4 ± 0.2 cm while the circumference of the nest was 27.9 ± 0.8 cm. These measurements are more or less similar to those reported by Ali and Ripley (1983) and Maduramozhi (2008). It builds a tunnel 207.5 cm above the ground and 96.6cm from the top of the river banks. Cornwell (1963) reported that the Belted Kingfisher add scientific name constructed a nest at least five feet above the ground and 12 - 18 inches from the top of the embankment, near the bottom of the organic soil layer. The agricultural lands, groves, perch sites and electric lines were closer to the nest-sites. The agricultural lands and groves provided a variety of protein rich insects and other prey to the growing nestlings as well as to the parents. 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).

In the present study, mean clutch size was 3.7; clutch size 3 was the most common (58% of 15 nests), followed by 31% of clutch 5 and 11% of clutch 4. Ali and Ripley (1983) reported that the clutch size of white-breasted kingfisher as 4 - 7. Maduramozhi (2008) recorded ten clutches of the White-breasted Kingfisher in Nagapattinam, Southern India, all are having 4 eggs. Several factors might contribute to clutch size variability *viz*., 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 nest-lings (Klomp, 1970; O'Connor, 1984; Lessels and Krebs, 1989). The White-breasted Kingfisher was found to lay roundish oval eggs with a mean length and width of 34.8 and 26.6 mm and weighing 8.9 g. Maduramozhi (2008) reported that egg measurements for the White-breasted Kingfisher that is, mean length, width and weight were 34.1, 25.8 mm and 5.5 g. Egg measurements in the present study are in full agreement with those of the previous report.

The weight of chicks on the first day was 3.7 g which increased to 70.5 g at 24 days of age. However, there was a drop in the mean weight of nestlings in last few days and reached 61.8 g at the time of fledging. Many observers have noted a decrease in rate-of-gain in weight as feathers were being produced or as temperature con-trol was being established. Welty (1982) stated that many nestlings lost body weight a few days before leaving the nest. This loss was supposed to be due to the utilization of fat deposits and skeletal muscles for the energy to leave the nest. This body weight reduction is advan-tageous for moving out of the nest (Kumar and Rao, 1984; Haggerty, 1994; McCarty, 2001; Penteriani et al., 2005; Greeny, 2008; Asokan et al., 2009b,c, 2010). The development of the different structure of the nestlings was not uniform throughout the nestling period. The body length, bill length, wing length, wing span, tail length and tarsus length attained the maximum maturity at the time of fledging stage. The White-breasted Kingfisher used above body parts immediately after fledging for successful survival. This kind of growth allometry in the adaptive parts had been observed in several avian species (Zach and Mayoh, 1982; Kumar, 1983; Teather, 1996; Aparicio, 2001; Pereyra and Morton, 2001; Asokan et al., 2009b,c, 2010).

This research revealed that the overall breeding success rate for the period of hatching to fledgling was 75%. The similar value was reported in White-breasted Kingfisher by Madhuramozhi (2008). The clutches with 4 or 5 eggs had the maximum mortality. All the nests with 5 eggs lost at least an egg in hatching stage and they produced a maximum of 3 or 4 fledglings. We have found that food shortage and starvation to be responsible for the largest number of nestling mortality. Another important factor for breeding losses by the White-breasted Kingfisher was human disturbances especially small village boys to broken and burned the nests hole for fun. Such other important factors like habitat security, presence of predators, food resources, the proximity and low distance between nesting site and food resources and also appropriate weather conditions were also ensuring overall reproductive success of this species.

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