Habitat-related Density and Activity Patterns of the White-breasted Kingfisher *Halcyon smyrnensis* in Cauvery Delta, Southern India

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Abstract: Population density and activity patterns of the White-breasted Kingfisher *Halcyon smyrnensis* were studied in the Cauvery Delta of Tamil Nadu, Southern India from 2004 to 2006. Population density was estimated by a line transect method. White-breasted Kingfisher density varied between 70 and145 individuals per square km. The river-banks generally supported highest numbers than agricultural lands or social forests. The White-breasted Kingfisher population showed year-on-year variations in all three habitats, reaching, respectively, high densities during 2005 (137/km^2), 2006 (125/km^2) and 2006 (95/km^2). Significant seasonal density variations in each habitat were also recorded (P<0.05). Field observations of the species' diurnal activities during four time blocks in the day showed that they spent an average of 54% of their time scanning, 23% feeding, 13% flying, 6% preening and 4% resting. Time spent on feeding and flying activities did not change (P>0.05) between years and seasons, but varied (P<0.05) among time blocks. Scanning and resting activities differed between years (P<0.05) and seasons (P<0.05) (in 2006), but did not differ (P>0.05) among time blocks and habitats. Preening varied between years (P<0.05), seasons (P<0.05) (in 2006) and among time blocks. The present study could be useful in planning the conservation measures and population management strategies for avian species in the study area.

***Keywords*:** Feeding, *Halcyon smyrnensis*, population, preening, resting, scanning.

INTRODUCTION

White-breasted Kingfisher *Halcyon smyrnensis* is a common species of a variety of habitats, mostly open country in plains with trees, electric wires and other perches. It is found in Turkey, northern and central Israel, Egypt through to Iraq, Iran, Afghanistan, north-western India (Ali & Ripley 1983) and parts of Southeast Asia (Fry *et al.* 1992, del Hoyo *et al.* 2001).

They feed mainly on a variety of agriculturally-damaging insect pests (Asokan *et al*. 2009), but also on crustaceans (Roza 1995), earthworms (Yahya & Yasmin 1991), rodents, fish and frogs (Roberts & Priddy 1965). A little information is available on the occurrence, feeding and breeding of White-breasted Kingfisher in some parts of India (Mukherjee 1975, Hore *et al*. 1991, Yahya & Yasmin 1991, Balasubramanian 1992, Sen 1994, Oommen & Andrews 1996, 1998, Srinivasalu 2004, Asokan *et al*. 2009, Palkar *et al*. 2009, Ali *et al*. 2010 a, b).

However, detailed behavioural studies of this species are scarce not only in India but also in West Asia. Hence the present study aims at investigation of the population density and diurnal activity patterns of the White-breasted Kingfisher in different time blocks, seasons and habitats in the Cauvery Delta of Tamil Nadu, Southern India.

STUDY AREA

The study was conducted in three villages (Mannampandal, Manakudi and

Thiruvalanagadu) located in the Cauvery Delta in Nagapattinam District (18°18'N, 79°50'E, an area of some 150 km^2), Tamil Nadu, Southern India. The region is generally referred to as the 'granary of South India' because of large-scale agricultural operations taking place for the cultivation of paddy, sugarcane, cotton, groundnut, banana, pulses (green and black grams, *Vigna* spp.) and other cereals. Woods are sparse and in the form of groves and roadside trees. Predominant tree species found in the study area are: *Madhuca longifolia, Mangifera indica, Enterolobium saman, Tamarindus indicus, Ficus benghalensis, Ficus religiosa, Thespesia populnea, Acacia arabica, Lannea coromandelica* and *Azadirachta indica.* Important shrub species are: *Prosopis juliflora, Jatropha glandulifera* and *Adhathoda vasica.* Plantations of casuarina *Casuarina equisetifolia,* teak *Tectona grandis* and thorny bamboo *Bamboosa arundinacea* are also found within in the study area. The northeast monsoons usually bring rain to the study area from October to December (65% of the total rainfall in a year) and the dry seasons occurs between May and July.

The present study was carried out in three different habitats, namely agricultural lands, river-banks (whose vegetation comprised a host of trees, shrubs and herbs on both sides of the river) and social forestry plantations; in each, three 1000×100m transects were marked for intensive bird censuses. The 'agricultural lands' are under cultivations of paddy, sugarcane and plantain; 'river-bank' terrain is characterized by the predominance of riverside vegetation and the 'social forests' include a variety of village woodlots, especially such as casuarina, bamboo, teak, eucalyptus.

MATERIALS AND METHODS

Population data were collected twice in every month from February 2004 to December 2006 while data on activity patterns were collected monthly between January 2005 and December 2006 in the three study habitats. The study years were divided based on rainfall and temperature, into the following seasons: post-monsoon (January–March), summer (April–June), pre-monsoon (July–September) and monsoon (October–December).

Population density

We used the line transect method of Gaston (1975) to estimate the population density of the White-breasted Kingfisher. Although there are many methods for the estimation of bird populations, the line transect method is better-suited to our study area, which predominantly is open, sparsely distributed with trees. In each habitat, three one-kilometre long transects were selected following a preliminary survey undertaken one month earlier. The birds were censused within a 50m belt on either side of transects (100 m wide strip). All census operations were carried out immediately after sunrise, from 06:00 to 08:00 hrs. Transects were walked at a rate of 0.75 to 1.00 km/hr. Censuses were carried out fortnightly during the study period in all the three habitats. However, bird counts were not carried out on cloudy, rainy or windy days, but were deferred to the following day. Double counting was avoided by allowing for the direction of movements of the birds. To estimate the bird densities as number per sq. km. the following formula was used: D= Number of birds / (2×L×W), where L= Length of transect and W= ½ width of transect (Gaston 1975).

Time activity patterns

Observations were made with 7×50 binoculars and the duration of activities was measured with an electronic stopwatch. Each day was divided into four time blocks: early morning (06:00–09:00), late morning (09:00–12:00), midday or afternoon (12:00–15:00) and late evening (15:00–18:00). Behavioural data were collected using the focal animal sampling technique of Altmann (1974). The pattern of observation in each time block was: in each one hour, there were three 15-minute continuous monitoring periods followed by a 5-minute break. During each 15-minute period, only one bird was monitored. The time spent in different activities was calculated each month, and from these values the percentage of time spent was estimated for each activity during different time blocks of the day. The activities are divided into five major categories:

(1) Feeding – the time spent by birds in capturing the prey and manoeuvring them into the mouth prior to swallowing'.

(2) Flying – the time spent by birds in flight, very often in pursuit of prey.
(3) Scanning – birds perching in an upright position and scanning their surroundings actively.
(4) Resting – perched birds that were sleeping or dozing, with the head retracted and eyes closed.
(5) Preening – consisted of all forms of comfort movements including feather shaking, wing flapping, bill cleaning, bill scratching, body-shaking and tail-shaking.

Statistical analysis

One-way ANOVA was also used to compare the mean population density between seasons and years. We compared each diurnal activity for the period 2005 to 2006 (seasons and time blocks pooled) using *t*-student tests. We used One-way Analysis of Variance (ANOVA) to compare each activity among time blocks and habitats (years, seasons and habitats pooled) and seasons within years. Statistical analyses were performed using MINITAB package (Minitab Inc. 2006). We found that population data were normally distributed while the behavioural data were not.

RESULTS

Population density

The population density of the White-breasted Kingfisher varied from 70/km^2 (monsoon 2004, social forests) to 145/km^2 (summer 2005, agricultural lands). In general, the river-banks supported relatively higher numbers of White-breasted Kingfishers per km^2 than the others (Table 1). Within the habitats, the densities were highest during the summers of 2004 to 2006 in agricultural lands and river-banks. In social forests, the highest densities were recorded during the summers of 2004 and 2005 and during the pre-monsoon of 2006. Annual mean densities (across all seasons) inferred that the river-banks had higher mean densities in 2005 (137/km^2) and the agricultural lands and social forests had higher densities in 2006 (Table 2). Significant yearly variations in White-breasted Kingfisher densities existed in the river banks ($F_{2,32}$=8.74, P<0.01) and social forests ($F_{2,32}$=4.63, P<0.05). Within the seasons, the agricultural lands (137/km^2), river banks (135/km^2) and social forests (99/km^2) had higher densities during the summer than in other seasons (Table 3). Significant seasonal variations in White-breasted Kingfisher densities were observed in all the three habitats (ANOVA, P<0.05) (Table 3).

Time activity patterns

Overall, the White-breasted Kingfisher spent 54% of its diurnal time on scanning, which varied between the years (53.5% in 2005 and 54.1% in 2006) (t_{22}=4.2, P<0.05). In 2005, scanning activity was similar ($F_{3,44}$=0.81, P>0.05) between seasons, but birds spent more time scanning ($F_{3,44}$=6.32, P<0.05) post-monsoon than in other seasons in 2006 (Table 4). Scanning was similar ($F_{3,44}$=1.61, P>0.05) among the time blocks, but in general birds allocated more time in the mid-day block than in any other (Table 5). Time spent for scanning was similar (t_8=0.9, P>0.05) in all habitats (Table 6).

White-breasted Kingfishers spent an average of 23% of their diurnal time on feeding, which did not vary between the years (t_{11}=1.5, P>0.05) or between the seasons ($F_{3,44}$=1.74, P>0.05) within the years (Table 4). Feeding activity varied ($F_{3,44}$=8.56, P<0.01) among the time blocks and was higher in the morning (22.5%) and evening (25.6%) than at mid-day (15.1%; Table 5). They fed most often (t_{11}=4.1, P<0.05) in agricultural lands (23.4%) than in river-banks (Table 6). White-breasted Kingfishers spent an average of 13% of their diurnal time on flying, which did not vary between the years (t_{14}=1.3, P>0.05) and between the seasons ($F_{3,44}$=0.11, P>0.05) within the years (Table 4). Flying activity varied ($F_{3,44}$=3.14, P<0.05) among the time blocks of the day and always peaked during the 09:00–12:00 block (Table 5). Most of the flight activity was feeding-related for all time blocks, season and habitats.

White-breasted Kingfishers spent an average of 6% of their diurnal time in preening activities. These activities were higher in 2005 than in 2006 (t_{12}=4.3, P<0.05). In 2005, time allocated to these activities did not change ($F_{3,44}$=1.78, P>0.05) between seasons; in 2006, they spent more time ($F_{3,44}$=9.29, P<0.01) during the pre-monsoon than the other seasons (Table 4). Preening activities varied

($F_{3,44}$=11.74, P<0.01) among time blocks of the day, and it always peaked at the midday (Table 5). Preening activities were occurred similarly (t_9=1.5, P>0.05) in all habitats (Table 6).

White-breasted Kingfishers spent 4% of their diurnal time in resting activity. This activity was lower (t_{14}=3.2, P<0.05) in 2005 than in 2006. In 2005, time allocated to this activity did not change ($F_{3,44}$=1.59, P>0.05) between the seasons. In 2006, they spent less time ($F_{3,44}$=7.61, P<0.01) resting during the summer than the other seasons (Table 4). They were equally rested (P>0.05) at all times of the day ($F_{3,44}$=0.88, P>0.05) (Table 5) and all habitats (t_{11}=1.1, P>0.05) (Table 6).

Table 1. Variations in the population density (birds/km^2) of White-breasted Kingfisher, by habitat and season, from 2004–2006 inclusive. Values are mean ± SD.

Year	Season	Habitats		
		Agricultural lands	**River-banks**	**Social forests**
2004	Post-monsoon	94 ± 10.0	121 ± 28.1	81 ± 13.1
	Summer	131 ± 25.1	130 ± 11.4	94 ± 24.6
	Pre-monsoon	105 ± 18.2	117 ± 18.0	72 ± 14.1
	Monsoon	105 ± 18.3	95 ± 06.1	70 ± 05.2
2005	Post-monsoon	102 ± 25.3	136 ± 26.2	77 ± 19.2
	Summer	145 ± 27.0	144 ± 15.1	103 ± 25.2
	Pre-monsoon	122 ± 23.8	139 ± 21.6	87 ± 16.4
	Monsoon	106 ± 18.0	128 ± 18.2	79 ± 17.5
2006	Post-monsoon	136 ± 30.0	123 ± 23.3	89 ± 12.3
	Summer	138 ± 20.1	133 ± 21.6	101 ± 19.0
	Pre-monsoon	114 ± 21.7	128 ± 23.2	102 ± 15.1
	Monsoon	113 ± 15.4	122 ± 21.8	89 ± 12.4

Table 2. Yearly variations in the density (birds/km^2) of White-breasted Kingfisher in the three study habitats in 2004 to 2006 inclusive. Values are mean ± SD. *****Differences between years (P<0.05).

Habitat	Year			ANOVA		
	2004	**2005**	**2006**	**df**	***F***	***P***
Agricultural lands	110 ± 23.1	119 ± 19.1	125 ± 16.2	2,32	1.68	0.201
River banks	115 ± 18.3	137 ± 08.3	127 ± 09.2	2,32	8.74	0.000*
Social forests	79 ± 16.5	86 ± 14.3	95 ± 08.1	2,32	4.63	0.017*

Table 3. Seasonal variations in the density (birds/km^2) of White-breasted Kingfisher in the three study habitats in 2004 to 2006 inclusive. Values are mean ± SD. *****Differences between seasons (P<0.05).

Habitat	Year				ANOVA		
	Post-monsoon	**Summer**	**Pre-monsoon**	**Monsoon**	**df**	***F***	***P***
Agricultural lands	112 ± 23.6	138 ± 15.2	114 ± 17.2	108 ± 11.4	2, 31	5.85	0.002*
River banks	127 ± 11.1	135 ± 10.6	128 ± 15.6	115 ± 16.2	2, 31	3.42	0.029*
Social forests	82 ± 12.8	99 ± 14.4	87 ± 15.1	79 ± 09.1	2, 31	4.26	0.012*

Table 4. Mean percentage of diurnal time spent in various activities by White-breasted Kingfisher in the Cauvery Delta, southern India. POM= post-monsoon; SUM= summer; PRM= pre-monsoon; MON= monsoon, *Differences (*t*-test, *P*<0.05) between years, **Differences (One-way ANOVA, *P*<0.05) between seasons.

Activity	2005					2006				
	POM	SUM	PRM	MON	Mean	POM	SUM	PRM	MON	Mean
Feeding	21.3	27.1	22.6	18.9	22.4	24.0	28.2	20.8	20.1	23.2
Flying	11.6	14.0	15.6	15.3	14.1	9.3	15.5	12.6	14.3	13.0
Scanning	56.7	47.3	52.8	57.4	53.5*****	58.6**	49.4**	52.2**	56.2**	54.1*
Resting	4.1	2.7	5.1	2.6	3.7*****	4.2**	3.6**	6.3**	5.0**	4.8*
Preening	6.3	8.9	3.9	5.8	6.2*****	3.9**	3.3**	8.1**	4.4**	4.9*

Table 5. Mean percentage of diurnal time spent in various activities by White-breasted Kingfisher in different time blocks (years, seasons and habitats pooled) in the Cauvery Delta, southern India. *Differences (One-way ANOVA, *P*<0.05) between time blocks.

Activity	Time blocks (hours)				Mean
	06:00–09:00	09:00–12:00	12:00–15:00	15:00–18:00	
Feeding	22.5	18.3	15.1	25.6	20.4*
Flying	13.3	14.1	13.9	12.9	13.6*
Scanning	54.5	56.6	58.3	51.5	55.2
Resting	3.9	6.1	6.9	2.3	4.8
Preening	5.8	4.9	5.8	7.7	6.1*

Table 6. Mean percentage of diurnal time spent in various activities by White-breasted Kingfisher among habitats (years, seasons and time blocks pooled) in the Cauvery Delta, southern India. *Differ (One-way ANOVA, *P*<0.05) between habitats.

Activity	Agricultural lands	River-banks	Social forestry	Mean
Feeding	23.4	20.9	18.3	22.2*
Flying	11.8	12.5	10.6	12.2*
Scanning	55.4	58.3	58.4	56.9
Resting	4.1	3.2	5.8	3.7
Preening	5.3	5.1	6.9	5.2

DISCUSSION

The White-breasted Kingfisher densities were related to habitat type, the river banks generally supporting higher densities and social forests the lowest. We conclude that the greater density of White-breasted Kingfishers along river-banks was due to favourable features such as greater vegetation densities and suitable soils for nest excavation, as found for Small Bee-eater *Merops orientalis* by Asokan *et al*. (2003). In river-bank vegetation, the White-breasted Kingfisher generally perched on trees and would rest amongst shady vegetation, suggesting the vegetation is an important factor in relation to kingfisher density. Non-plantation river-side vegetation has an abundance of exposed-branch perches, unlike the local plantation forests. The availability of suitable sites for easy excavation of nests at the river banks is probably another contributing factor to their preference by this species, the pattern

correlating well with those by Asokan *et al.* (2003) for the Small Bee-eater. In general terms, the relationship between availability of nest sites and bird numbers has been well documented for a number of predatory birds (Cody 1985, Faanes 1987, Ilg & Johnson 1997, Fernandez-Juricic 2005, Asokan *et al.* 2003). The agricultural lands ranked second to river-banks in the White-breasted Kingfisher densities probably due to a relatively rich supply of insects and other prey; Asokan *et al.* (2003) and Sivakumaran & Thiyagesan (2003) have shown that food resources are frequently the most important density-dependent factor for insectivorous birds such as Green Bee-eater *Merops orientalis* and Indian Roller *Coracias benghalensis*. The White-breasted Kingfisher's least preference for social forests, in general, might be due to lower food availability.

Seasonal variations of White-breasted Kingfisher densities revealed that in all the habitats the monsoon period showed low densities. Higher numbers were observed from the beginning of the post-monsoon period to the end of the pre-monsoon period, reaching a peak density in the summer period, possibly related to the reproductive period of this species, because the White-breasted Kingfisher breeding season in the study area starts in March and ends in June. The high densities recorded in the summer (April–June) and Pre-monsoon (July–September) probably also reflects the addition of newly-independent juveniles. During this time, food availability is also high because insects increase in abundance (Asokan *et al.* 2003, 2009). The low density estimates during the monsoon and post-monsoon periods may be associated not only with the post-reproductive period but also with fewer resources during the cold season, juveniles having dispersed widely by then. We did not research possible reasons for yearly variations of numbers of this species, but it is likely that predation, intra- and interspecific-competition, parasites and diseases, habitat availability, weather, food habits and migration status may be factors (Lancaster & Rees 1979, Andrewartha & Birch 1984, Menge & Sutherland 1987, Pulliam 1988, Rosenzweig 1991, Chamberlain *et al.* 1999, Asokan *et al.* 2003).

The scanning activity was the most time-consuming activity for White-breasted Kingfishers. The White-breasted Kingfisher is a 'sit-and-wait' predator and so they spent the majority of their daytime for searching the prey. Scanning is a widespread behaviour amongst predatory birds (*e.g.* Ettinger & King 1980, Mahabal 1991, Sivakumaran & Thiyagesan 2003). The scanning activity was greater in the monsoon and post-monsoon periods and lower in the summer. During the monsoon, the study area was generally in wet condition due to the northeast monsoon rainfall that greatly affected prey species' (mainly insects) distributions. In the post-monsoon period, cold temperatures might be expected to force kingfishers to devote more time to scanning, while the reverse might be true during the summer. The amounts of time spent on scanning activity within time blocks and habitats by the White-breasted Kingfisher were inversely correlated to the availability of prey. When insect or other prey was abundant, the White-breasted Kingfisher spent less time scanning; when prey was in short supply, the reverse was true.

The White-breasted Kingfisher had a typically bimodal feeding pattern, one during the morning (06:00-09:00 hrs) and another during the evening (15:00–18:00 hrs) as shown for other species in such habitats *e.g.* (Natarajan 1991, Evers 1994, Ramachandran 1998, Rodway, 1998, Asokan 1995, Sivakumaran & Thiyagesan 2003). Feeding activity in the late evening may reflect their need for their overnight energy requirements (Kelly 1998). Differences in recorded seasonal feeding activity inferred that they fed more often during the summer and less during the monsoon. In the study area, food resources were generally abundant during the summer, and so the study species took a variety of prey, from insects to large crabs (Asokan *et al.* 2009), but in these habitats, insects predominated. Feeding activity was greater in the agricultural lands, because the prey spectrum is wider. The till, plant, harvest and fallow cycle of many crops represent dynamic habitats that on a small scale are unpredictable in terms of prey abundance and availability, but on the larger scale provide year-round feeding opportunities. Less time spent on the river-banks and social forest may reflect not only lower insect availability during the time blocks, but also higher avian predator pressure and greater human disturbance. However, the amount of time spent in feeding does also reflect the effect of variation in air

temperature, the time of the day and the presence of microhabitats (unpublished data).

Overall, the White-breasted Kingfisher spent 6% of its diurnal time on preening. The wings, breast and back were the body parts most often preened by White-breasted Kingfishers, followed by the tail, neck, rump and feet. The most frequent comfort activities were bill scratching, feather shaking and wing flapping. Time spent on this kind of body maintenance activities typically has been recorded in several bird species (Fischer 1981, Khera & Kalsi 1986, Natarajan 1991, Ramachandran 1998, Martinez 2000, Muzaffar 2004).

Earlier, many researchers found that resting is a major midday activity of birds (Verbeek 1972, Quinlan & Baldassarre 1984, Losito *et al*. 1990, Lee 1997, Martinez 2000). In the present study, White-breasted Kingfishers spent an average of 4% of the daytime for resting with a peak during the midday. Sleeping was the major diurnal resting activity for the White-breasted Kingfisher. The species generally rested in dense shaded trees and on electric power lines. Tamisier (1976) had suggested increase in resting in midday as a mechanism to minimize the heat load on a bird at high environmental temperatures.

In conclusion, due to their potential role as biological pest control agents, White-breasted Kingfishers have been identified as agriculturally beneficial birds (Asokan *et al*. 2009b). Our study provided some detailed numerical data for the population density and diurnal activities of the White-breasted Kingfisher in the Cauvery delta of Southern India and could be useful in planning the conservation measures and population management strategies for avian species in the study area. Future studies are planned to cover other ecological aspects of the White-breasted Kingfisher and of other bird species, with the aim of developing coherent conservation strategies.

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REFERENCES

Ali A.M.S., Asokan S. & Radhakrishnan P. 2010a. Observations on physical development of White-breasted Kingfisher (Aves: Alcedinidae *Halcyon smyrnensis*) nestlings in Cauvery delta region. *College Sadhana* **2(2):** 127–132.

Ali A.M.S., Asokan S. & Manikannan R. 2010b. Observations on nesting ecology of White-breasted Kingfisher *Halcyon smyrnensis* (Aves: Coraciiformes) in Cauvery Delta, Southern India. *Journal of Ecology and the Natural Environment* **2(7):** 134–139.

Ali, S. & Ripley, S.D. 1983. *Handbook of Birds of India and Pakistan*. Oxford University Press, Bombay.

Altmann J. 1974. Observational study of behaviour: Sampling methods. *Behaviour* **49:** 227–267.

Andrewartha H.G. & Birch L.C. 1984. *The ecological web*. University of Chicago Press, Chicago.

Asokan S. 1995. *Ecology of the Small Green Bee-eater, Merops orientalis Latham 1801 with special reference to its population, feeding and breeding in Mayiladuthurai, Tamil Nadu, South India*. Ph.D. Thesis, Bharathidasan University, Thiruchirappalli, India.

Asokan S., Thiyagesan K. & Nagarajan R. 2003. Studies on *Merops orientalis* Latham 1801 with special reference to its population in Mayiladuthurai, Tamil Nadu. *Journal of Environmental Biology* **24 (4):** 477–482.

Asokan S., Ali A.M.S. & Manikannan R. 2009. Diet of three insectivorous birds in Nagapattinam District, Tamil Nadu, India - a preliminary study. *Journal of Threatened Taxa* **1(6):** 327–330.

Balasubramanian P. 1992. New nesting site of the Indian White-breasted Kingfisher*Halcyon smyrnensis fusca* (Boddaert). *Journal of the Bombay Natural History Society* **89:** 124.

Chamberlain, D.E., Wilson J.D. & Fuller R.J. 1999. A comparison of bird populations on organic and conventional farm systems in southern Britain. *Biological Conservation* **88:** 307–320.

Cody M.L. 1985. An introduction to habitat selection in birds. ***In:*** Cody M.L. (Ed.)., *Habitat selection in birds*. Academic Press, Oriando, FL., pp. 3–56.

Ettinger A.O. & King J.R. 1980. Time and energy budgets of the Willow Flycatcher (*Empidonax traillii*) during the breeding season. *Auk* **97:** 533–546.

Evers D.C. 1994. Activity budgets of a marked Common Loon (*Gavia immer*) nesting population. *Hydrobiology* **279&280:** 415–420.

Faanes C.A. 1987. Breeding birds and vegetation structure in western North Dakota wooded draws. *Prairie Nature* **19:** 209–220.

Fernandez-Juricic E. 2002. Can human disturbance promote nestedness? A case study with breeding birds in urban habitat fragments. *Oecologia* **131:** 269–278.

Fischer D.H. 1981. Winter time budgets of brown thrashers. *Journal of Field Ornithology* **52(4):** 304–308.

Fry, CH, K Fry and A Harris. 1992. *Kingfishers, Bee-eaters & Rollers*. Helm. London.UK.

Gaston A.J. 1975. Estimating bird population. *Journal of the Bombay Natural History Society* **72:** 271–283.

Hore B.B., Mehrotra P.N. & Hore H. 1991. The rituals of egg laying in Indian White Breasted Kingfisher. *Zoo's Print Journal* **6(7):** 9–10.

del Hoyo, J, A Elliot and J Sargatal. 2001. *Handbook of the Birds of the World. Vol 6*. Lynx Edicions, BirdLife International. Barcelona, Spain/Cambridge, UK.

Ilg L. & Johnson D. 1997. Changes in breeding bird population in North Dakota: 1967 to 1992-93. *Auk* **114:**74–92.

Kelly J.F. 1998. Behaviour and energy budgets of Belted Kingfishers in winter. *Journal of Field Ornithology* **69(1):** 75–84.

Khera S. & Kalsi R.S. 1986. Diurnal time budgets of the Bank Myna *Acridotheres ginginianus* (Sturnidae) during prelaying, laying and incubation period. *Pavo* **25:** 25–32.

Lancaster R.K. & Rees W.E. 1979. Bird communities and the structure of urban habitats. *Canadian Journal of Zoology* **57:** 2358–2368.

Lee S. 1997. A time budget study of wintering mallards on the Southern High Plains of Texas, USA. *Korean Journal of Biological Science* **1:** 571–576.

Losito M.P., Mirarchi R.E. & Baldassarre G.A. 1990. Summertime activity budget of hatching-year mourning doves. *Auk* **107:** 18–24.

Mahabal A. 1991. Activity-time budget of Indian Myna *Acridotheres tristis* (Linnaeus) during the breeding season. *Journal of the Bombay Natural History Society* **90:** 96–97.

Martinez C. 2000. Daily activity patterns of Great Bustards *Otis tarda*. *Ardeola* **47(1):** 57–68.

Menge B.A. & Sutherland J.P. 1987. Community regulation: variation in disturbance, competition, and predation in relation to environmental stress and recruitment. *American Naturalist* **130:** 730–757.

Minitab Inc. 2006. Minitab Statistical Software, Release 15 for Windows, State College, Pennsylvania.

Mukherjee A.K. 1975. Food-habits of water-birds of the Sundarban, 24 Paraganas District, West Bengal. India-V. *Journal of the Bombay Natural History Society* **72:** 85-109.

Muzaffar S.B. 2004. Diurnal time-activity budgets in wintering Ferruginous Pochard *Aythya nyroca* in Tanguar Haor, Bangladesh. *Forktail* **20:** 25–27.

Natarajan V. 1991. Time budgeting by the Southern Crow-pheasant (*Centropus sinensis paaaoti*) at Point Calimere, Tamil Nadu. *Journal of the Bombay Natural History Society* **90:** 92–95.

Oommen M. & Andrews M.I. 1996. Awakening, roosting and vocalization behaviour of the Whitebreasted Kingfisher *Halcyon smyrnensis fusca* (Boddaert). *Pavo* **(34):** 43–46.

Oommen M. & Andrews M.I. 1998. Food and feeding habits of the White-breasted Kingfisher *Halcyon smyrnensis*. ***In*:** Dhindsa M.S., Shyamsunder P. & Parasharya B.M. (Eds.), *Birds in Agriculture Ecosystem*, Society for Applied Ornithology (India), pp. 132–136.

Palkar S.B., Lovalekar R.J. & Joshi V.V. 2009. Breeding biology of White-breasted Kingfisher *Halcyon smyrnensis*. *Indian Birds* **4:** 104–105.

Pulliam H.R. 1988. Sources, sinks and population regulation. *American Naturalist* **132:** 652–661.

Quinlan E.E. & Baldassarre G.A. 1984. Activity budgets of non-breeding Green-winged Teal on Playa lakes in Texas. *Journal of Wildlife Management* **48:** 838–845.

Ramachandran N.K. 1998. Activity patterns and time budgets of the Pheasant-tailed (*Hydrophaslanus chirurgus*) and Bronzewinged (*Metopidius indicus*) Jacanas. *Journal of the Bombay Natural History Society* **95:** 234–245.

Roberts T.J. & Priddy C. 1965. Food of the White-breasted Kingfisher *Halcyon smyrnensis* (Linnaeus). *Journal of the Bombay Natural History Society* **62(1):** 152–153.

Rodway M.S. 1998. Activity patterns, diet and feeding efficiency of Harlequin Ducks breeding in northern Labrador. *Canadian Journal of Zoology* **76:** 902–909.

Rosenzweig M.L. 1991. Habitat selection and population interactions: the search for mechanisms. *American Naturalist* **137:** 5–28.

Roza T. 1995. Crab-eating by White-breasted Kingfisher *Halcyon smyrnensis* (Linn.). *Journal of the Bombay Natural History Society* **92(1):** 121.

Sen, S.N. 1994. Food of the White-breasted Kingfisher (*Halcyon smyrnensis* fusca). *Journal of the Bombay Natural History Society* **44(3):** 475.

Sivakumaran N. & Thiyagesan K. 2003. Population, diurnal activity patterns and feeding ecology of the

Indian Roller (*Coracias benghalensis*). *Zoos' Print Journal* **18:** 1091–1095.

Srinivasulu C. 2004. Albinism in White-breasted Kingfisher *Halcyon smyrnensis* (Linn.) from India. *Journal of the Bombay Natural History Society* **101(1):** 157.

Tamisier A. 1976. Diurnal activities of Green-winged Teal and Pintail in Louisiana. *Wildfowl* **27:** 19–32.

Verbeek N.A.M. 1972. Daily and annual time budget of the Yellow-billed Magpie. *Auk* **89:** 567–582.

Yahya H.S. & Yasmin S. 1991. Earthworms in the dietary of the White-breasted Kingfisher *Halcyon smyrnensis* (Linn.). *Journal of the Bombay Natural History Society* **88:** 454.