Bangladesh J. Zool. **51**(2): 175-190, 2023 ISSN: 0304-9027
eISSN: 2408-8455

COMPARATIVE DIURNAL ACTIVITY PATTERNS OF *MEROPS LESCHENAULTI* AND *MEROPS ORIENTALIS* AT CHITTAGONG UNIVERSITY CAMPUS, BANGLADESH

Tanzina Alam[1*], Md. Mizanur Rahman[2]

Department of Zoology, Noakhali Science and Technology University, Noakhali-3814, Bangladesh.

ABSTRACT: A study was conducted on the diurnal activity patterns of chestnut-headed bee-eater (*Merops leschenaulti*) and green bee-eater (*Merops orientalis*) at Chittagong University Campus, Bangladesh in the year 2015. Six major activities (perching, flying, calling, feeding, diving, and preening) were recorded for both species during the study period. The two bee-eater species were observed to spend their maximum (*M. leschenaulti*: 37.63%; *M. orientalis*: 35.95%) time in perching, whereas the minimum time spent by *M. leschenaulti* was observed in diving (1.76%) and by *M. orientalis* was in feeding (2.17%). They were more active during 15:00 - 17:00 h (*M. leschenaulti*: 27.34%; *M. orientalis*: 27.23%) than other diurnal time blocks. Two species spent their highest (*M. leschenaulti*: 14.71%; *M. orientalis*: 14.00%) time performing different activities in June and the lowest (*M. leschenaulti*: 2.71%; *M. orientalis*: 3.46%) in January. Both bee-eaters were mostly (*M. leschenaulti*: 56.58%; *M. orientalis*: 53.07%) active in monsoon than in other seasons. The similar activity patterns between two bee-eater species could be influenced by similar lifestyles associated with their close taxonomic relationship. A number of ecological factors, such as temperature, humidity and precipitation could influence the daily, monthly and seasonal variations in activities.

Key words: Diurnal activity patterns, chestnut-headed bee-eater, green bee-eater, perching, monthly activity patterns, seasonal activity patterns

INTRODUCTION

The study of activity patterns quantifies the time allocation of animals concerning their behavioural activities (Rave and Baldassarre 1989, Ali and Asokan 2015) and it gives ideas about the individual's life history, physical condition, social structure, and ecological factors (Asokan *et al.* 2010, Ali and Asokan 2015, Ameha and Afework 2018). The daily activity patterns of birds are usually influenced by several factors such as habitat, weather and season (Bull 1997, Yihune and Bekele 2010, Biswas *et al.* 2014); and it often varies among and within species (Gulliemain *et al.* 2002, Jeschke and Tollrian 2005, Ali and

*Author for correspondence: tanzina@nstu.edu.bd; [2]*Department of Zoology, University of Chittagong, Chittagong-4331, Bangladesh.*
 DOI: https://doi.org/10.3329/bjz.v51i2.70777

Asokan 2015). The time spent on different activities greatly depends on the types of habitats they inhabit and the food they eat (Paulus 1984, Ali and Asokan 2015). Therefore, the time-activity budget is especially appropriate for comparative studies among the species, seasons of the year, sexes, and diurnal time blocks (Sutherland 2000, Ali and Asokan 2015, Ameha and Afework 2018). Several studies were conducted on activity patterns of bird species, including small bee-eater (Ali and Asokan 2015), common kingfisher (Sultana and Sarker 2016) and pied kingfisher and stork billed kingfisher (Biswas et *al.* 2014).

Two congeneric bee-eater species, chestnut-headed bee-eater (*Merops leschenaulti*) and green bee-eater (*Merops orientalis*) occur sympatrically in the Chittagong University Campus. Although these two bee-eaters differ in body size, both species are diurnal and perch on wire and bare branches of trees (Islam and Kamruzzaman 2008). They mostly feed on large-winged insects, such as dragonflies, bees, ants, termites, and butterflies (Islam and Kamruzzaman 2008, Alam and Rahman 2021). They are effective in pest management because they catch and control insect pest populations (Mishra 2019). However, the activity patterns of birds are supposed to be associated with individual needs and interaction within or between species (Yihune and Bekele 2010, Ali and Asokan 2015). Therefore, together with the daily, monthly, and seasonal activity patterns of a species, a comparative analysis is important to understand the behaviour of a species. Moreover, the activity patterns of these two bee-eaters have not yet been studied in Bangladesh. Detailed information on the activities of these two bee-eaters would be supportive to understand their behavioural patterns and movements.

The goals of the present study were to (1) evaluate the activity patterns in different diurnal blocks, months, and seasons, (2) compare the activity patterns of these two bee-eater species, and (3) focus on the possible factors related to those trends in activity patterns of these two bee-eater species.

MATERIAL AND METHODS

Description of the Study area: The Chittagong University Campus (CUC) is located at the village Fatehpur under Hathazari Upazila of Chittagong District, and it is about 3 km southwest of Hathazari upazila headquarters and 22 km north of the Chittagong city (Ahsan and Khanom 2005, Biswas *et al.* 2014). The campus area lies approximately between latitude 22°24 N and longitude 91°50 E (Islam *et al.* 1979, Alam and Rahman 2021) and comprises 709.79 ha (1753.88 acres) of land, of which 72% land consists of hills and hillocks; and remaining area either plains or valleys (Islam *et al.* 1979, Biswas *et al.* 2014, Alam and Rahman 2021). The 30% of hilly areas are higher than 70 m whereas 60% of

hills are less than 30 m high, and the valleys are almost 15-90 m high from the sea surface (Islam *et al.* 1979, Biswas *et al.* 2014). The campus areas have about 665 species of plants under 404 genera and 126 families (Alam and Pasha 1999) and 215 species of birds representing 63 families (Ahsan *et al.* 2017, Alam and Rahman 2021). The present study was conducted in four distinct sites of the CUC (Fig. 1):

Site-A: Institute of Forestry and Environmental Science of Chittagong University (IFESCU): IFESCU is located on the south side of the Chittagong University Campus. It covers a large area with beautiful natural resources. This area is covered with different species of trees including Akashmoni (*Acacia moniliformis*), Coconut (*Cocos nucifera*), Koroi (*Albizzia spp.*), Garjan (*Dipterocarpus spp.*), Kanthal (*Artocarpus heterophyllus*), Shegun (*Tectona grandis*), etc. (Ahsan and Khanom 2005, Biswas *et al.* 2014). Various species of birds are abundant in this area including bee-eaters.

Site-B: Botanical Garden and its surrounding areas: The botanical garden has been established on the southern side of the CUC. It occupies about 24.28 ha (60 acres) of undulated land area for the conservation of both indigenous and exotic plant species. There are about 10,000 plants of 400 species comprising over 150 families of both exotic and indigenous species including Aam (*Mangifera indica*), Bot (*Ficus benghalensis*), Boroi (*Zizyphus mauritiana*), Coconut (*Cocos nucifera*), Jhau (*Casuarina equisitifolia*), Koroi (*Albizzia spp.*), Kanthal (*Artocarpus heterophyllus*), etc. (Ahsan and Khanom 2005, Biswas *et al.* 2014). Many species of birds are observed here.

Site-C: Hill bottom colony and its surrounding areas: Hill bottom colony is situated on the west side of CUC. Although this is a residential area, this area is covered with small to moderate hills, water bodies and some vegetation. This area is diversified with a large number of birds including bee-eaters and other animals.

Site-D: Kata pahar and its surrounding areas: Kata pahar is situated at the entrance of CUC. Broken hills are present on both sides of the road. Hills are covered with various species of plants including Garjan (*Dipterocarpus* spp.), Shegun (*Tectona grandis*), Koroi (*Albizzia* spp.), Bandar lathi/Sonalu (*Cassia fistula*) etc. (Ahsan and Khanom 2005, Biswas *et al.* 2014). Varieties of birds and some species of mammals are found in this area.

Study procedure: The present study was conducted from January to December 2015. Activity patterns of bee-eaters were recorded by dividing the whole day period into four-time blocks based on two hours intervals viz., 07:00-09:00 h, 09:00-11:00 h, 11:00-13:00 h and 15:00-17:00 h. Six days were spent per month in the field to observe birds. Data were collected using the scan

sampling method proposed by Altmann (1974) based on 05 minutes intervals (Akhtar *et al.* 2009, Biswas *et al.* 2014). In each scan, the activities of one individual were recorded. When the individual disappeared from our sight, another individual was selected and its activities were recorded.

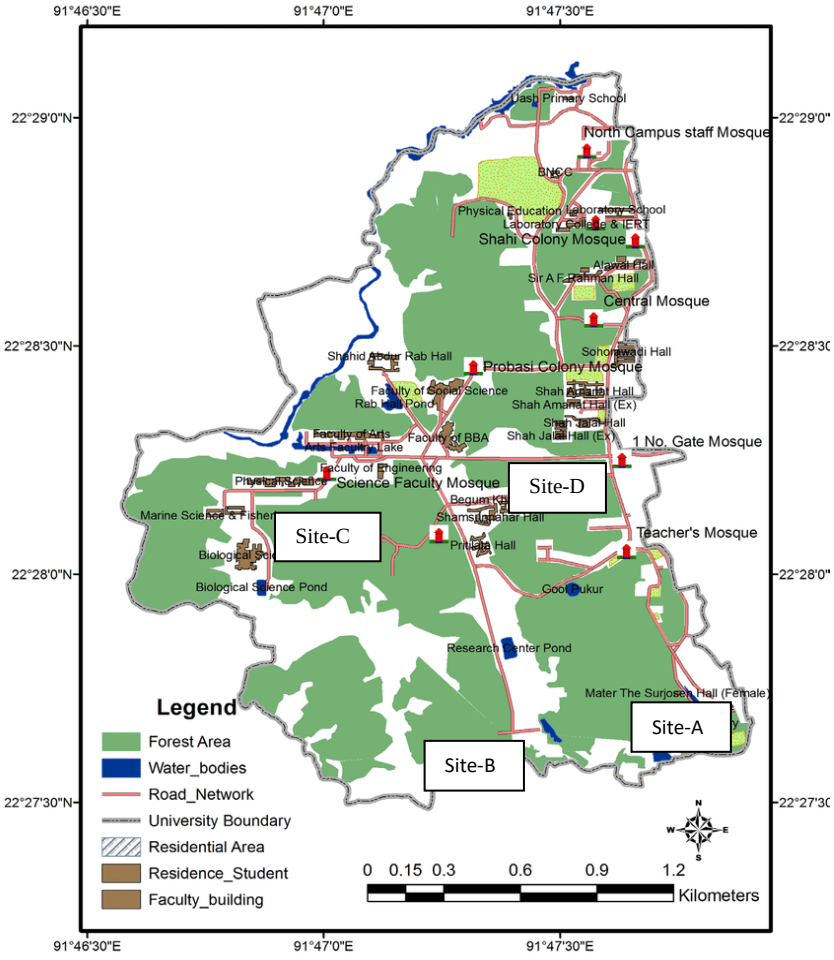


Fig. 1: Map of the study sites of the CUC area.

The timing of the fieldwork was selected based on the activity and visibility of two studied species and observations were made by walking through the existing roads. The activities of the studied species were observed using binoculars and/or naked eyes. A stopwatch was also used to record the duration of different activities performed by two bee-eater species. We collected data on the diurnal activities of each bee-eater species for 576 hours. Daily, as well

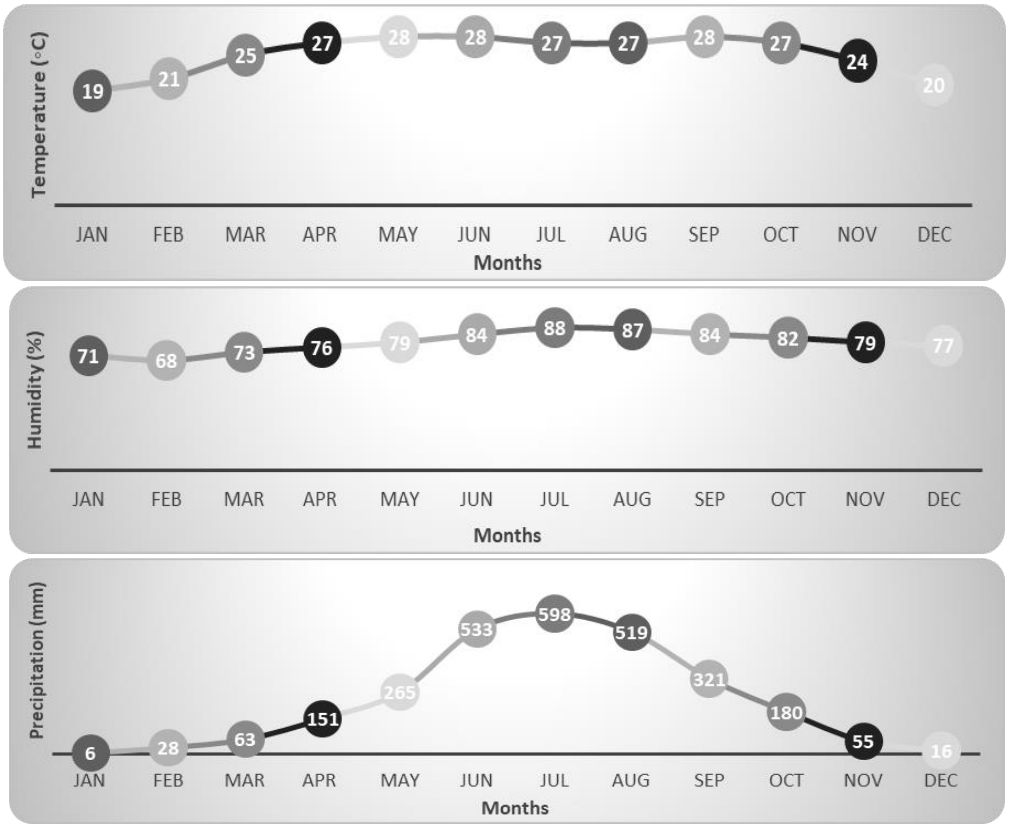


Fig. 2 Temperature, humidity and precipitation throughout the study period.

monthly, and seasonal activities [Summer (March to May), Rainy season/ Monsoon (June to October) and Winter (November to February)] were also calculated (Ahmad 1968).

The activities were categorized into six (perching, flying, calling, feeding, diving, and preening) major types for two bee-eater species.

(1) Perching: Time spent by the bee-eaters resting and scanning their surroundings sitting on a perch was considered perching.
(2) Flying: It refers to the flight of the bee-eaters from their habitat to other places and flying around their home range and territory.
(3) Calling: Time spent by bee-eaters for producing voice calls.
(4) Feeding: It refers to the time spent by the study species in capturing the prey and swallowing it.
(5) Diving: It includes the time spent by the bee-eaters trying to capture prey from a perch but unable to capture it.

(6) Preening: It refers to the time spent by the birds to clean themselves.

Data analysis: The time-activity index (TAI) was calculated for both species by using the following formula:

TAI (%) = TTA×100 / TDO (Morrier and McNeil 1991, Borah 2011, Biswas *et al.* 2014)

Here, TTA = total time (s) spent in a particular activity during the surveillance period, and TDO = total duration of observation used for the species.

The diurnal activities of both species were collected daily basis. The variation in daily, monthly and seasonal activities was figured and obtained results for both species were compared using the F-test. Microsoft Excel 2007 software was used for the F test. The results are reported as significant if they are associated with a value of $p<0.05$.

RESULTS AND DISCUSSION

General activity patterns: During the study period, six major activities (perching, flying, calling, feeding, diving and preening) were observed and recorded for both bee-eater species; whereas Ali and Asokan (2015) described five major activities (scanning, feeding, flying, resting and preening) of green bee-eater in both dry and wet seasons in Southern India.

Out of 5,907 scans of different activities, chestnut-headed bee-eaters spent the highest (37.63%) time in perching and the lowest (1.76%) time in diving (Table 1 & 2); whereas out of 6,512 scans, green bee-eaters spent the maximum (35.95%) time in perching and the minimum (2.17%) time in feeding (Table 1 & 2). The time spent in different activities between the two bee-eaters did not differ significantly (F = 1.0844331, df = 5, p = 0.4656452). Both of the bee-eater species spend most of their day time sitting on a perch and searching for insect prey. Similarly, Ali and Asokan (2015) reported that green bee-eaters spent the highest (52.5%) of their daytime in scanning activities. Perching is reported as the most frequent activity in some kingfishers and rollers too (Asokan *et al.* 2010, Yihune and Bekele 2010, Biswas *et al.* 2014).

Daily activity patterns: Both bee-eater species were more active during 15:00-17:00 h (chestnut-headed bee-eaters: 27.34%; green bee-eaters: 27.23%) and less active during 11:00-13:00 h (chestnut-headed bee-eaters: 22.67%; green bee-eaters: 21.78%) (Fig. 3). The daily activity patterns between two bee-eaters at different time blocks were not differed significantly (F = 0.597052, df = 3, p = 0.341097).

Monthly and seasonal activity patterns: The two bee-eater species spent the maximum (chestnut-headed bee-eaters: 14.71%; green bee-eaters: 14.00%) time in different activities in June and the minimum (chestnut-headed bee-eaters:

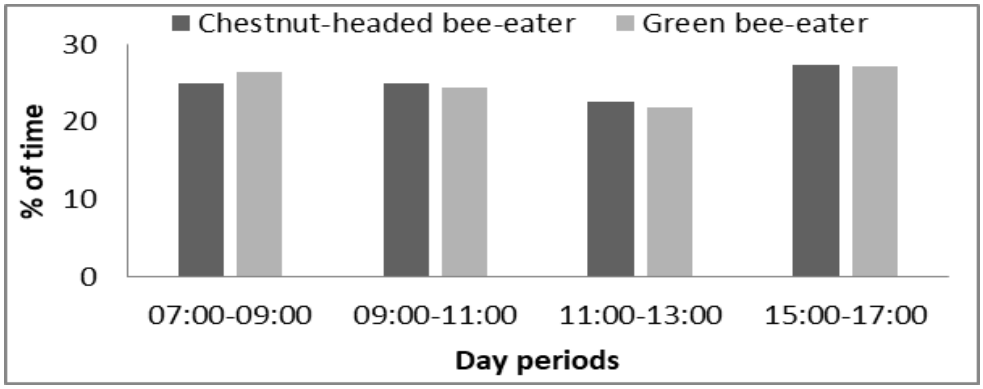


Fig. 3 Variation in daily activity patterns between two bee-eaters in different time blocks.

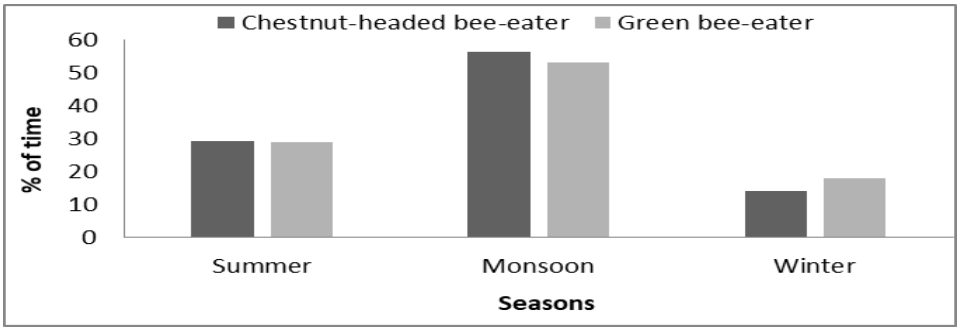


Fig. 4 Variation in seasonal activity patterns of two bee-eater species.

2.71%; green bee-eaters: 3.46%) time in January (Table 1). The monthly activities of the two bee-eaters did not vary significantly (F = 1.6141688, df = 11, p = 0.2198675). During June the temperature was highest and in January the temperature was lowest (Fig. 2). It indicates that the diurnal activities of bee-eaters increase in high temperature and decrease in low temperature. Both of the bee-eaters were more (chestnut-headed bee-eaters: 56.58%; green bee-eaters: 53.07%) active in monsoon and less (chestnut-headed bee-eaters: 14.03%; green bee-eaters: 18.04%) active in winter (Fig. 4). Time spent in seasonal activities by two bee-eater species did not differ significantly (F= 1.44376, df = 2, p = 0.409206). During the monsoon the temperature, humidity and precipitation were higher (Fig. 2). These environmental factors might have a relationship to the diurnal activities of both studied species. Common kingfisher and pied kingfisher were also reported to be mostly active in the rainy season than in other seasons. (Biswas *et al.* 2014, Sultana and Sarker 2016)

Perching: Chestnut-headed bee-eaters spent the highest (32.57%) time in perching during 15:00-17:00 h and the lowest (15.25%) during 07:00-09:00 h, whereas green bee-eaters also spent the maximum (33.36%) time in perching

during 15:00-17:00 h and minimum(15.59%) time during 09:00-11:00 h (Fig. 5), which did not differ significantly between two bee-eater species (F = 0.9784390, df = 3, p = 0.4930623). The perching activity was highest during the late evening (15:00-17:00) because after performing different activities all day long they sit on a perch and rest in the late evening. Ali and Asokan (2015) reported that green bee-eaters spent the highest (48.2 ± 18.24%) time in perching during midday (12:00-15:00 h).

Besides, both bee-eaters spent the highest (chestnut-headed bee-eaters: 5.11%; green bee-eaters: 4.82%) time in perching in June and the lowest (chestnut-headed bee-eaters: 1.05%; green bee-eaters: 1.29%) time in January (Table 1), which did not vary significantly between two bee-eaters (F = 1.6983903, df = 11, p = 0.1965966).

As well, the perching activity between the two bee-eaters was almost similar in different seasons and it did not vary significantly (F = 1.646143, df = 2, p = 0.377908). Both of the bee-eaters spent the maximum (chestnut-headed bee-eaters: 57.44%; green bee-eaters: 52.24%) time in perching during the rainy season and the minimum (chestnut-headed bee-eaters: 14.04%; green bee-eaters: 18.54%) in the winter (Fig. 6). Maximum perching activity during the rainy season might be due to increased precipitation (Fig. 2). The two bee-eaters were observed to perch in bushes and shady areas so that they can protect themselves from rainwater. Similarly, Ali and Asokan (2015) described that the green bee-eaters spent more time in scanning during monsoon and post-monsoon in Southern India.

Flying: Chestnut-headed bee-eaters spent the maximum (34.75%) time in flying during 07:00-09:00 h and the minimum (14.32%) during 15:00-17:00 h; whereas green bee-eaters spent the highest (34.51%) time during 09:00-11:00 h and the lowest (13.99%) during 15:00-17:00 h (Fig. 5); and this activity didn't differ significantly between the two bee-eater species in different day periods (F = 0.79444, df = 3, p = 0.4272326). In the morning bee-eaters require lots of energy to perform their daily activities. For this reason, they fly from one place to another in search of food. Human disturbance is another important reason for flight. The presence of humans in the forest to harvest timber and food makes birds frightened and they leave the place considering it dangerous. Ali and Asokan (2015) reported that the green bee-eaters spent more time (20.1 ± 6.40) in flying during the late evening (15:00-18:00 h) in Southern India.

As well, flying activity was the highest in June (chestnut-headed bee-eaters: 3.2%; green bee-eaters: 3.03%) and the lowest (chestnut-headed bee-eaters: 0.75%; green bee-eaters: 0.86%) in January for both bee-eater species (Table 1). The time spent in flying activity between the two species did not differ significantly in different months (F = 1.5100460, df = 11, p = 0.2527588).

In addition, both of the bee-eaters used their maximum (chestnut-headed bee-eaters: 53.62%; green bee-eaters: 51.30%) time in flying activity in monsoon and minimum (chestnut-headed bee-eaters: 17.45%; green bee-eaters: 20.52%) in winter (Fig. 6); which did not differ significantly between two species in different seasons (F = 1.330411, df = 2, p = 0.429109). Bee-eaters avoid flying during heavy rain and long periods of rain bring the risk of starvation. So, when the rain stops the need to feed and forage becomes urgent. Ali and Asokan (2015) described that the green bee-eaters spent more time in flying during the summer in Southern India.

Calling: Chestnut-headed bee-eaters were more (44.54%) active in calling during 07:00-09:00 h and less (10.61%) during 11:00-13:00 h; whereas green bee-eaters spent the maximum (40.27%) time in calling during 09:00-11:00 h and the minimum (15.18%) during 15:00-17:00 h (Fig. 5), which was almost similar and did not differ significantly between two bee-eater species (F = 1.8560659, df = 3, p = 0.3120791). Bee-eaters chose morning as a perfect time for calling because they feel energetic in the fresh air of the morning. Besides, in the morning chances are low to be spotted by predators.

As well, both of the bee-eaters spent the maximum time in calling in June (chestnut-headed bee-eaters: 2.47%; green bee-eaters: 2.40%) and minimum time in January (chestnut-headed bee-eaters: 0.41%; green bee-eaters: 0.55%) (Table 1); which didn't differ significantly between two species in different months (F = 1.6302738, df = 11, p = 0.2151993). Month June is the breeding season of both bee-eater species. Male bee-eaters spent more time in calling activities to attract females for courtship.

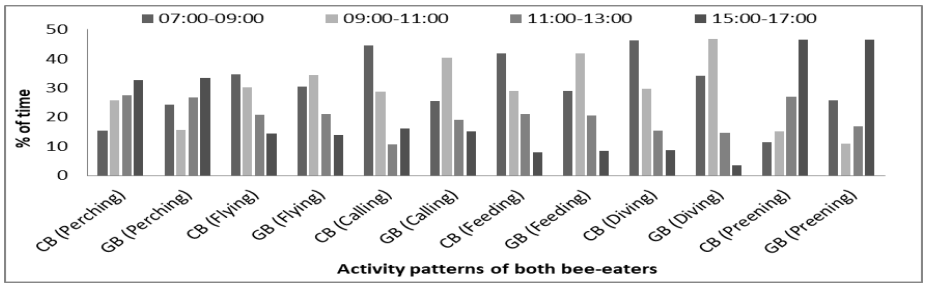
In addition, both of the bee-eaters spent the highest time (chestnut-headed bee-eaters: 55.56%; green bee-eaters: 52.91%) in calling during monsoon and the lowest (chestnut-headed bee-eaters: 13.71%; green bee-eaters: 17.00%) in winter (Fig. 6); which was more or less similar and did not vary significantly between two species (F = 1.341135, df = 2, p = 0.427143).

Feeding: Chestnut-headed bee-eaters spent the maximum (41.94%) time in feeding during 07:00-09:00 h and the minimum (8.06%) during 15:00-17:00 h; whereas green bee-eaters were more active (41.84%) in feeding during 09:00-11:00 h and less (8.51%) during 15:00-17:00 h (Fig. 5); which did not differ significantly between two species (F = 1.024726, df = 3, p = 0.4922259). Both species spent more time in feeding in the morning because they have to increase their energy reserve to stay active for the whole day. Ali and Asokan (2015) described that the green bee-eaters spent more time in feeding in the morning (06:00-09:00) and evening (15:00-18:00) in Southern India. Some studies on other birds such as southern crow-pheasant (Natarajan 1991), common loon

(Evers 1994) and indian roller (Sivakumaran and Thiyagesan 2003) also stated that birds spent more time in feeding during morning and evening.

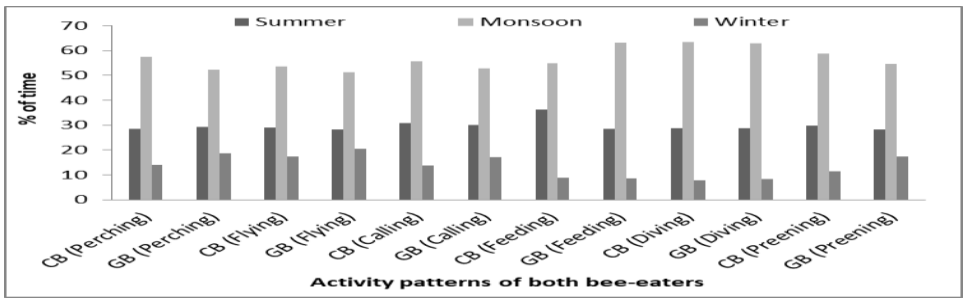
As well, chestnut-headed bee-eaters spent the maximum (0.41%) time in feeding in June and the minimum (0.03%) both in December and January; whereas green bee-eaters spent the maximum (0.43%) time in feeding in June and the minimum (0.02%) in January (Table 1), which did not differ significantly between two species ($F = 1.0724708$, $df = 11$, $p = 0.4548531$).

Besides, the feeding activity between the two bee-eaters was almost similar in different seasons and it did not vary significantly ($F = 1.428466$, $df = 2$, $p = 0.411783$). Both of the bee-eaters were more (chestnut-headed bee-eaters: 54.84%; green bee-eaters: 63.12%) active in feeding during monsoon and less (chestnut-headed bee-eaters: 8.87%; green bee-eaters: 8.51%) active during winter (Fig. 6). More feeding activity during the rainy season might be due to the abundance of insects after heavy rain. Another reason could be, the temperature was higher during the rainy season (Fig. 2). The extreme heat causes a loss of huge energy. So, they fed more to stay active. Ali and Asokan (2015) reported that the green bee-eaters spent more time in feeding during summer in Southern India.



CB: Chestnut-headed bee-eater, GB: Green bee-eater

Fig. 5 Activity patterns of both bee-eater species in different time blocks.



CB: Chestnut-headed bee-eater, GB: Green bee-eater

Fig. 6 Activity patterns of both bee-eater species in different seasons.

Diving: The diving activity was almost the same and it did not vary significantly (F = 0.7336440, df = 3, p = 0.4025763) between the two bee-eaters in different day periods. Chestnut-headed bee-eaters spent the highest (46.15%) time in diving during 07:00-09:00 h and the lowest (8.65%) during 15:00-17:00 h; but green bee-eaters utilised the maximum (46.85%) time during 09:00-11:00 h and the minimum (3.5%) during 15:00-17:00 h (Fig. 5). Bee-eaters mainly dive to catch their prey. In the morning the rate of diving is high to collect their food and gain energy for the entire day.

Moreover, the two bee-eaters utilised their maximum (chestnut-headed bee-eaters: 0.36%; green bee-eaters: 0.38%) time in diving in June and minimum (chestnut-headed bee-eaters: 0.02%; green bee-eaters: 0.03%) in January (Table 1), that did not differ significantly between two species (F = 0.9297498, df = 11, p = 0.4530070).

As well, diving activity was approximately similar and did not differ significantly between the two species (F = 1.042635, df = 2, p = 0.489564). It was recorded highest (chestnut-headed bee-eaters: 63.46%; green bee-eaters: 62.94%) in the rainy season and in winter diving activity was lowest (chestnut-headed bee-eaters: 7.69%; green bee-eaters: 8.39%) for both bee-eater species (Fig. 6). The highest diving activity in monsoon might be due to extremely hot weather to feed more and run their activities all day long (Fig. 2).

Preening: The preening activity was more or less related and did not differ significantly between the two species (F = 1.0235816, df = 3, p = 0.4925814). Chestnut-headed bee-eaters spent the highest (46.42%) time in preening during 15:00-17:00 h and the lowest (11.38%) time during 07:00-09:00 h; whereas green bee-eaters used the maximum (46.50%) time in preening during 15:00-17:00 h and the minimum (10.96%) time during 09:00-11:00 h (Fig. 5). Similarly, Ali and Asokan (2015) described that in green bee-eaters preening activity is maximum (10.2 ± 5.59%) in the late evening (15:00-18:00 h) in Southern India. After passing a busy day in the evening bee-eaters take a rest and clean themselves. They were observed to preen their wings, breast and tail. These activities have been recorded in bank myna (Khera & Kalsi 1986), pheasant-tailed and bronze-winged jacanas (Ramachandran 1998), great bustard (Martinez 2000) and white-breasted kingfisher (Ali *et al.* 2010).

As well, both of the bee-eaters spent the highest (chestnut-headed bee-eaters: 3.17%; green bee-eaters: 2.95%) time in preening in June and the lowest (chestnut-headed bee-eaters: 0.46%; green bee-eaters: 0.71%) time in January (Table 1); that did not differ significantly between two species in different months (F = 1.9779053, df = 11, p = 0.1366587).

Table 1. Diurnal activity patterns of chestnut-headed bee-eater and green bee-eater in the year 2015.

Months	Perching (Scan)		Flying (Scan)		Calling (Scan)		Feeding (Scan)		Diving (Scan)		Preening (Scan)		Total (Scan)	
	CB	GB	CB	GB	CB	GB	CB	GB	CB	GB	CB	GB	CB	GB
January	62	84	44	56	24	36	2	1	1	2	27	46	160	225
	1.05%	1.29%	0.75%	0.86%	0.41%	0.55%	0.03%	0.02%	0.02%	0.03%	0.46%	0.71%	2.71%	3.46%
February	103	122	76	88	52	54	4	4	3	3	41	63	279	334
	1.74%	1.87%	1.29%	1.35%	0.88%	0.83%	0.07%	0.06%	0.05%	0.05%	0.69%	0.97%	4.72%	5.13%
March	123	174	78	104	56	83	8	6	3	8	46	91	314	466
	2.08%	2.67%	1.32%	1.60%	0.95%	1.27%	0.14%	0.09%	0.05%	0.12%	0.78%	1.40%	5.32%	7.16%
April	227	228	151	141	112	113	15	13	11	15	139	122	655	632
	3.84%	3.50%	2.56%	2.17%	1.90%	1.74%	0.25%	0.20%	0.19%	0.23%	2.35%	1.87%	11.09%	9.71%
May	284	282	159	178	139	135	22	21	16	18	147	149	767	783
	4.81%	4.33%	2.69%	2.73%	2.35%	2.07%	(0.37%	0.32%	0.27%	0.28%	2.49%	2.29%	12.98%	12.02%
June	302	314	189	197	146	156	24	28	21	25	187	192	869	912
	5.11%	4.82%	3.20%	3.03%	2.47%	2.40%	0.41%	0.43%	0.36%	0.38%	3.17%	2.95%	14.71%	14.00%
July	297	294	184	186	142	142	21	23	17	23	152	164	813	832
	5.03%	4.51%	3.11%	2.86%	2.40%	2.18%	0.36%	0.35%	0.29%	0.35%	2.57%	2.52%	13.76%	12.78%
August	278	267	148	159	119	121	12	18	14	19	142	147	713	731
	4.71%	4.10%	2.51%	2.44%	2.01%	1.86%	0.20%	0.28%	0.24%	0.29%	2.40%	2.26%	12.07%	11.23%
September	233	196	113	122	106	96	8	12	9	14	134	111	603	551
	3.95%	3.00%	1.91%	1.87%	1.79%	1.47%	0.14%	0.18%	0.15%	0.21%	2.27%	1.70%	10.21%	8.46%
October	167	152	85	106	42	67	3	8	5	9	42	88	344	430
	2.83%	2.33%	1.40%	1.63%	0.71%	1.03%	0.05%	0.12%	0.08%	0.14%	0.71%	1.35%	5.82%	6.60%
November	79	131	63	96	34	55	3	5	2	4	31	61	212	352
	1.34%	2.01%	1.07%	1.47%	0.58%	0.84%	0.05%	0.08%	0.03%	0.06%	0.52%	0.94%	3.59%	5.41%
December	68	97	51	68	27	42	2	2	2	3	28	52	178	264
	1.15%	1.49%	0.86%	1.04%	0.46%	0.64%	0.03%	0.03%	0.03%	0.05%	0.47%	0.80%	3.01%	4.05%
Total	2223	2341	1341	1501	999	1100	124	141	104	143	1116	1286	5907	6512
	37.63%	35.95%	22.70%	23.05%	16.91%	16.89%	2.19%	2.17%	1.76%	2.20%	18.89%	19.75%	100%	100%

Moreover, both of the bee-eaters were more (chestnut-headed bee-eaters: 58.87%; green bee-eaters: 54.59%) active in preening during the rainy season and less (chestnut-headed bee-eaters: 11.38%; green bee-eaters: 17.26%) active during winter (Fig. 6); which was approximately related and did not differ significantly between two species (F = 1.556051, df = 2, p = 0.391229).

Table 2. Total time activity index (TAI) of chestnut-headed bee-eater and green bee-eater

Activities	TTA[1](Min)		TDO[2](Min)		TAI (%)	
	CB	GB	CB	GB	CB	GB
Perching	11,115	11,705	29,535	32,560	37.63	35.95
Flying	6,705	7,505	29,535	32,560	22.70	23.05
Calling	4,995	5,500	29,535	32,560	16.91	16.89
Feeding	620	705	29,535	32,560	2.19	2.17
Diving	520	715	29,535	32,560	1.76	2.20
Preening	5,580	6,430	29,535	32,560	18.89	19.75

[1]TTA: Total time spent in a particular activity during the observation period; [2]TDO: Total duration observation used for the species; CB: Chestnut-headed bee-eater; GB: Green bee-eater.

CONCLUSION

Daily activity patterns are useful in environmental monitoring, evaluation of habitat suitability and population management (Evers 1994, Hamilton *et al.* 2002, Jonsson and Afton 2006, Chen *et al.* 2008). The present study reveals that both bee-eater species spent most of their day time in perching or scanning activities and they were more active in monsoon than in other seasons. After considering all results, we can conclude that the almost similar activity patterns of two bee-eater species might be due to their occurrence in the same geographical region. And the daily, monthly and seasonal activities of both bee-eater species are influenced by environmental factors, such as temperature, humidity and precipitation. Changes in environmental factors cause changes in the activities and behaviour of both bee-eater species.

LITERATURE CITED

AHMAD, N. 1968. Geography of East Pakistan. Oxford University Press, Oxford. 401 pp.

AHSAN, M. F. and KHANOM, N. 2005. Birds of the Chittagong University Campus, Chittagong. *The Chittagong University Journal of Science,* **29**(1), 77-88.

AHSAN, M. F., RAHMAN, M. M., KABIR, M. T. and ISLAM, M. M. 2017. A checklist of avian fauna of Chittagong University Campus. *Bangladesh Journal of Threatened Taxa,* **9**(6), 10325- 10333. https://dx.doi.org/10.11609/jot.1885.9.6.10325-10333

AKHTAR, S., KABIR, M. M., HASAN, M. K. and BEGUM, S. 2007. Activity pattern of pied kingfisher(*Ceryle rudis*) at Jahangirnagar University campus. *Bangladesh Journal of life Science,* **19**(1), 49-58.

AKHTAR, S., KABIR, M. M., BEGUM, S. and HASAN, M. K. 2009. Activity pattern of Bronze-winged Jacana (*Metopidius indicus*) at Jahangirnagar University Campus. *Bangladesh Journal of life Science*, **21**(2), 111–120.

ALAM, M. N. and PASHA, M. K. 1999. A floristic account of Chittagong University Campus. *The Chittagong University Journal of Science,* **23**(1), 81–99.

ALAM, T. and RAHMAN, M. M. 2021. Resource partitioning between two sympatric bee-eater species at Chittagong University campus. *Journal of Noakhali Science and Technology University,* **5**(1), 1-11.

ALI, A. M. S. and ASOKAN, S. 2015. Diurnal-activity patterns of the small bee-eater (*Merops orientalis*) in Southern India. *Tropical Life Science Research,* **26**(1), 9–20.

ALI, A. M. S., ASOKAN, S. and MANIKANNAN, R. 2010. Habitat-related density and activity patterns of the White-breasted Kingfisher *Halcyon smyrnensis* in Cauvery Delta, Southern India. *Podoces,* **5**(1), 54–62.

AMEHA, K. and AFEWORK, B. 2018. Diurnal activity patterns and feeding behaviour of African jacana (*Actophilornis africanus* Gmelin) in Lake Hawassa, Ethiopia. *Ethiopian Journal of Science,* **41**(2), 53–60.

ASOKAN, S., ALI, A. M. S., MANIKANNAN, R. and NITHIYANANDAM, G.T. 2010. Population densities and diurnal activity pattern of the Indian Roller *Coracias benghalensis* (Aves: Coraciiformes) in Nagapattinam District, Tamil Nadu, India. *Journal of Threatened Taxa,* **2**(10), 1185-1191DOI: 10.11609/JoTT.o2308.1185-91

ASOKAN, S., ALI, A. M. S. and MANIKANNAN, R. 2010. Breeding Biology of Small bee-eater *Merops orientalis* (Latham, 1801) in Nagapattinam District, Tamil Nadu, India. *Journal of Threatened Taxa,* **2**(4), 797-804. https://doi.org/10.11609/JoTT.o2273.797-804

BISWAS, J. K., SARKER, N. J., AHSAN, M. F. and RAHMAN, M. M. 2014. Activity patterns of pied kingfisher (*Ceryle rudis*) and storkbilled kingfisher (*Pelargopsis capensis*) at the Chittagong University campus, Bangladesh. *Bangladesh Journal of Zoology,* **42**(2), 191-203. https://doi.org/10.3329/bjz.v42i2.23355

BORAH, J. 2011. Occupancy pattern and food-niche partitioning among sympatric kingfishers in Bhitarkanika mangroves, Orissa. Unpublished M.S. (Wildlife Science) thesis. Wildlife Institute of India.

BULL, W. 1997. Daily variation in activity and flock size of two parakeet species from Southeastern Brazil. *Short Communications*, **109**, 343-348.

CHEN, T., LIN, Y. and DING, T. 2008. Time budget of polyandrous Pheasant-tailed Jacana (*Hydrophasianus chirurgus*) during breeding season in Taiwan. *Taiwania,* **53**(2), 107–115. http://dx.doi.org/10.6165/tai.2008.53(2).107

EVERS, D. C. 1994. Activity budgets of a marked Common Loon (*Gavia immer*) nesting population. *Hydrobiology,* **279–280**(1), 415–420. https://doi.org/10.1007/BF00027872

GUILLEMAIN, M., FRITZ, H. and DUNCAN, P. 2002. Foraging strategies of granivorous dabbling ducks wintering in protected areas of the French Atlantic Coast. *Biodiversity and Conservation,* **11**(10), 1721–1372. https://doi.org/10.1023/a:1020322032114

HAMILTON, A. J., TAYLOR, I. R. and HEPWORTH, G. 2002. Activity budgets of waterfowl (Anatidae) on a waste-stabilisation pond. *Emu,* **102**(2), 171–179 https://doi.org/10.1071/MU01050

ISLAM, A. T. N. T., CHOWDHURY, H. S. S., HOQUE, A. K. M. M. and MALIK, S. A. 1979. Detailed soil survey of Chittagong University campus, Chittagong. Preliminary edition. Department of the peoples Republic Bangladesh.

ISLAM, M. A. and KAMRUZZAMAN, M. 2008. *Merops leschenaulti*. In: Encyclopedia of flora and fauna of Bangladesh, vol. 26. Birds. (Ed., Siddiqui, K. U., Islam, M. A., Kabir, S. M. H., Ahmed, M., Ahmed, A. T. A., Rahman, A. K. A., Haque, E. U., Ahmed, Z. U., Begum, Z. N. T., Hassan, M. A., Khondker, M. and Rahman, M. M.) Asiatic Society of Bangladesh, Dhaka, pp. 80-81.

ISLAM, M. A. and KAMRUZZAMAN, M. 2008. *Merops orientalis*. In: Encyclopedia of flora and fauna of Bangladesh, vol. 26. Birds. (Ed., Siddiqui, K. U., Islam, M. A., Kabir, S. M. H., Ahmed, M., Ahmed, A. T. A., Rahman, A. K. A., Haque, E. U., Ahmed, Z. U., Begum, Z. N. T., Hassan, M. A., Khondker, M. and Rahman, M. M.) Asiatic Society of Bangladesh, Dhaka, pp. 81-82.

JESCHKE, J. M. and TOLLRIAN, R. 2005. Predicting herbivore feeding times. *Ethology,* **111**, 187–206. https://doi.org/10.1111/j.1439-0310.2004.01052.x

JÓNSSON, J. E. and AFTON, A. D. 2006. Different time and energy budgets of Lesser Snow Geese in rice-prairies and coastal marshes in southwest Louisiana. *Waterbirds,* **29**(4), 451–458. http://dx.doi.org/ 10.1675/1524-4695(2006)29[451:DTAEBO]2.0.CO;2

KHERA, S. and KALSI, R. S. (1986). Diurnal time budgets of the Bank Myna *Acridotheres ginginianus* (sturnidae) during pre-laying, laying and incubation periods. *Pavo,* **25**(1–2), 25–32.

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

MISHRA, S. 2019. The Ecology of Merops Orientalis. *International Journal of Scientific Research in Biological Sciences*, **6**, 12-14. https://doi.org/10.26438/ijsrbs/v6i5.1214

MORRIER, A. and MCNEIL, R. 1991. Time-activity budget of Wilson's and Semipalmated plovers in a tropical environment. *The Wilson Bulletin*, **103**(4), 598-620.

NAHER, H. 2012 Food habits, breeding biology and conservation issues of Kingfishers, *Alcedo atthis* and *Halcyon smyrnensis*. Unpublished Ph.D. Thesis. University of Dhaka, Dhaka. 282 pp.

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

PAULUS, S. L. 1988. Time-activity budgets of nonbreeding Anatidae: A review. In: Waterfowl in winter. (Ed. Weller, M.W.) University of Minnesota Press, Minneapolis, USA, pp.135–152.

RAMACHANDRAN, N. K. 1998. Activity patterns and time budgets of the Pheasant-tailed (*Hydrophaslanus chirurgus*) and Bronze-winged (*Metopidius indicus*) Jacanas. *Journal of the Bombay Natural History Society,* **95**(1), 234–245.

RAVE, D. P. and BALDASSARRE, A. 1989. Activity budget of Green Winged Teal wintering in coastal wetlands of Louisiana. *Journal of Wildlife Management,* **53**(3), 753–759. https://doi.org/10.2307/3809208

SIVAKUMARAN, N. and THIYAGESAN, K. 2003. Population, diurnal activity patterns and feeding ecology of the Indian Roller (*Coracias benghalensis*). *Zoos' Print Journal*, **18**, 1091-1095. DOI: 10.11609/JoTT.ZPJ.18.5.1091-5

SULTANA, M. and SARKER, N.J. 2016. Patterns of daily activities frequencies of Common Kingfisher (*Alcedo atthis*) in Nikunja-1, Dhaka. *International Journal of Fauna and Biological Studies*, **3**(5), 23-28

SUTHERLAND, W. J. 2000. The Conservation Handbook: Research, Management and Policy. Blackwell Science Ltd., London, 294pp.

YIHUNE, M. and BEKELE, A. 2010. Diet activity of pied kingfisher (*Ceryle rudis*) in Lake Hora Arsedi, Debrezeit. *Ethiopian Journal of Biological Science,* **9**(2), 117-125.

(Manuscript received on 20 March; 2023 revised on 10 August; 2023)