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Diurnal-activity Patterns of the Small Bee-eater (*Merops orientalis*) in Southern India

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Abstrak: Corak diurnal masa-aktiviti oleh burung Small Bee-eater (*Merops orientalis*) telah dikaji antara tahun 2005 hingga 2006 di daerah Nagapattinam di Selatan India. Burung Bee-eaters telah diperhatikan menggunakan secara puratanya sebanyak 52.2% daripada masa mereka untuk mengimbas, 21.3% untuk makan, 13.3% untuk terbang, 8.8% untuk berehat dan 4.1% untuk aktiviti menyelisik. Masa yang telah digunakan untuk mengimbas berbeza mengikut musim pada tahun 2005 (p<0.05) dan antara blok masa (p<0.05), tetapi tidak berbeza antara tahun dan habitat (p>0.05). Corak pemakanan berbeza antara tahun, musim antara tahun, blok masa dan habitat (p<0.05). Pola penerbangan berbeza antara tahun, blok masa dan habitat (p<0.05) tetapi tidak berubah antara musim dalam tahun (p>0.05). Pola berehat berbeza antara tahun dan habitat (p<0.05) tetapi tidak berbeza antara musim dalam tahun atau blok masa (p>0.05). Aktiviti menyelisik berbeza antara tahun dan blok masa (p<0.05) tetapi tidak berbeza antara musim dalam tahun atau habitat (p>0.05). Kami membuat kesimpulan bahawa beberapa faktor, seperti ketersediaan makanan, faktor persekitaran dan ancaman pemangsa, boleh memberi kesan terhadap corak aktiviti diurnal burung Bee-eaters antara habitat dan musim; kajian lanjut boleh menjernihkan kesimpulan ini.

Kata kunci: Small Bee-eater, Masa-aktiviti, Mengimbas, Pemakanan, Blok Masa, Musim

Abstract: The diurnal time-activity patterns of the Small Bee-eater (*Merops orientalis*) were studied between 2005 and 2006 in the Nagapattinam District of Southern India. Bee-eaters were observed to spend an average of 52.5% of their day time scanning, 21.3% feeding, 13.3% flying, 8.8% resting and 4.1% engaging in preening activities. The time spent on scanning varied among seasons in 2005 (p<0.05) and among time blocks (p<0.05), but it did not vary among years or habitats (p>0.05). The feeding patterns differed among years, seasons within years, time blocks and habitats (p<0.05). The flying habits varied among years, time blocks and habitats (p<0.05) but did not change between seasons within years (p>0.05). The resting habits differed among years and habitats (p<0.05) but did not differ among seasons within years or time blocks (p>0.05). Preening differed among years and time blocks (p<0.05) but did not vary among seasons within years or habitats (p>0.05). We conclude that several factors, such as food availability, environmental factors and predation threats, may affect the diurnal activity patterns of Bee-eaters between habitats and seasons; a further study could clarify this conclusion.

Keywords: Small Bee-eater, Time-activity, Scanning, Feeding, Time Blocks, Seasons

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INTRODUCTION

Activity pattern studies quantify the time allocation of animals performing behavioural activities (Rave & Baldassarre 1989). The amount of time allocated to various behaviours is therefore critical in understanding the ecological needs of a species and the pressures acting upon individuals of that species. From an animal's time activity pattern, we can learn more about its individual physical condition, social structure and environmental conditions (Paulus 1988; Aissaoui *et al*. 2011). Daily activity is influenced by an individual's need and its interactions with organisms, both conspecific and with other species. Animals modify their activities to maximise their energy gain and reproductive output. These conversions should vary according to the inherent factors of the animals, such as age, sex, mass and reproductive status (Corp *et al*. 1997); environmental factors, such as ambient temperature, humidity, illumination and precipitation; and ecological factors, such as group size, habitat, food availability and predation (Lillywhite & Brischoux 2012). The patterns of daily activity and behaviour often vary among and within species (Guillemain *et al*. 2002; Jeschke & Tollrian 2005); as a result, these activity patterns help us to study the life history and ecological adaptations of birds (Hamilton *et al*. 2002). The time and amount of energy a bird spends performing different activities must inevitably influence its survival. The time-activity patterns of birds vary greatly according to the type of habitats they inhabit and food they eat (Paulus 1984). Time-activity patterns are especially suitable for comparative studies, such as those among sexes, seasons of the year and habitats (Holmes *et al*. 1979).

Several studies have reported the diurnal activity pattern of various bird species (e.g., Morrier & McNeil 1991; Rave & Cordes 1993; Evers 1994; Martinez 2000; Acquarone *et al*. 2001; Muzaffar 2004; Baaziz & Samraoui 2008; Chen *et al*. 2008; Jónsson & Afton 2009). However, in the Indian context, information on the diurnal activity patterns of birds is limited, except for some preliminary works (e.g., Khera & Kalsi 1986; Mahabal 1991; Natarajan 1991; Ramachandran 1998; Sivakumaran & Thiyagesan 2003; Ali *et al*. 2010a, b; Asokan *et al*. 2010a; Upadhyaya & Saikia 2010; Das et al. 2011; Thakor *et al*. 2011, 2012; Yaseen *et al*. 2014).

Bee-eaters (family Meropidae) are one of 9 or 10 families in the order Coraciiformes (Fry 2001). There are 26 currently recognised species, which occur predominantly throughout the Afro-Asian tropics. There is considerable diversity in social and breeding behaviours among the Meropidae: they may perform colonial or solitary nesting, be sedentary or migratory, and utilise pair-breeding or a cooperative breeding system (Fry 2001; Burt 2002). The Small Bee-eater (*Merops orientalis*) is an abundant, widely distributed species that is found in western sub-Saharan Africa through the Middle East and in the Indian subcontinent to south Asia (Fry & Fry 1992). These birds are sexually monomorphic, and they feed upon airborne insects, predominantly beetles, bees, dragonflies, butterflies, bugs and grasshoppers, which they obtain by fly-catching from exposed perches (Asokan *et al*. 2009). Little information currently exists on the ecology of Small Bee-eaters (Bastawde 1976; Bannerjee 1992; Mishra 1993; Sihag 1993; Sridhar & Karanth 1993; Asokan 1998; Burt 2002; Milind *et al*. 2002;

Asokan *et al*. 2003, 2010b). In particular, data on the diurnal activity patterns of Small Bee-eaters are lacking. Here, we describe the time allocated to different daily activities by the Small Bee-eater among seasons, time blocks and habitats in a region of Southern India.

MATERIALS AND METHODS

Study Area

The study was conducted in three different locations, Mannampandal (11°.09' N, 79°.68' E), Manakkudi (10°.58' N, 79°.74' E) and Thiruvalanagadu (13°.12' N, 79°.78' E) of the Nagapattinam District, Tamil Nadu, Southern India. The study area is generally referred to as the 'granary of Southern India' because it hosts large-scale agricultural operations for the cultivation of rice (*Oryza sativa*), sugarcane (*Saccharum officinarum*), cotton (*Gossypium hirsutum*), groundnut (*Arachis hypogaea*), banana (*Musa paradisiaca*), green gram (*Vigna radiata*), black gram (*Vigna mungo*) and other cereals. Based on rainfall and temperature, the study years were divided into the following seasons: post-monsoon (January-March), summer (April-June), pre-monsoon (July-September) and monsoon (October-December). The activity patterns of Small Bee-eaters were observed in three habitats, namely agricultural lands (at Thiruvalanagadu), river banks (at Mannampandal) and social forestry plantations (at Manakkudi). The agricultural lands are under paddy cultivation; the river bank terrain is characterised by the host of trees, shrubs and herbs on both sides of the river; and the social forests include a variety of village woodlots, such as Casuarina, bamboo, teak and eucalyptus.

Diurnal Activity Patterns

Data were collected twice monthly between 2005 and 2006 in all three habitats. The observations were made with 7×50 field binoculars, and the duration of each of the activities was measured using an electronic stopwatch. Each day was divided into four time blocks: early morning (0600–0900 hrs), late morning (0900–1200 hrs), midday or afternoon (1200–1500 hrs) and late evening (1500–1800 hrs). Behavioural data were collected using the focal animal sampling technique of Altmann (1974). The pattern of observation in each time block was as follows: each hour was divided into three 15-minute continuous monitoring periods, followed by a 5-minute break. During each 15-minute period, only one bird was monitored, and the same bird was monitored throughout the day. When the bird disappeared from our sight, another individual was selected and monitored. Small Bee-eaters are sexually monomorphic, so we did not differentiate the data between sexes. The time spent performing different activities was determined each month, and from these values, the percentage of time spent was estimated for each activity during the different time blocks of the day. In each year, we collected data on the diurnal activities of Small Bee-eaters for 144 hours, for a total of 288 hours over 2 years for each habitat. The activities are divided into five major categories:

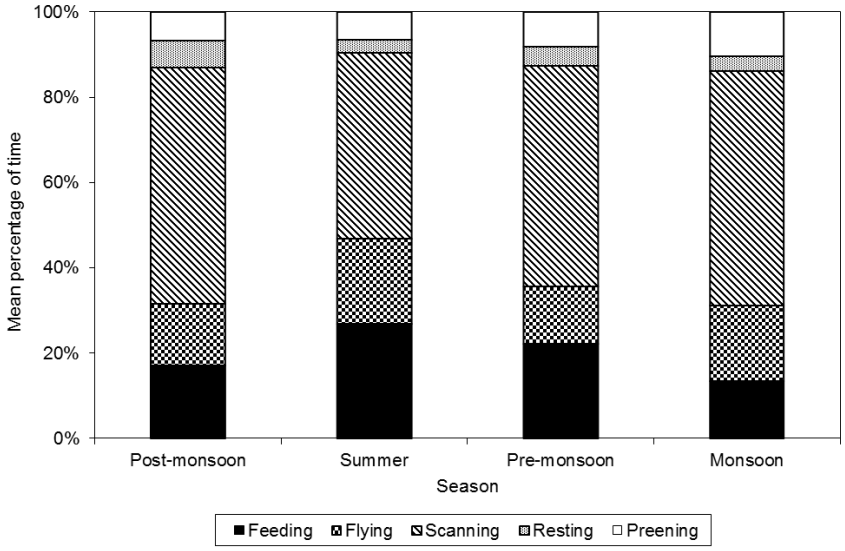
(1) Scanning – the time spend by the bird in an upright position, scanning its surroundings actively.
(2) Feeding – the time spent by a bird in capturing prey and manoeuvring them into its mouth prior to swallowing.
(3) Flying – the time spent by a bird in flight, very often in pursuit of prey.
(4) Resting – the time spent by a bird sleeping or dozing while perched, with its head retracted and eyes closed.
(5) Preening – the time spent on all forms of comfort movements, including feather shaking, wing flapping, bill cleaning, bill scratching, body-shaking and tail-shaking.

Data Analysis

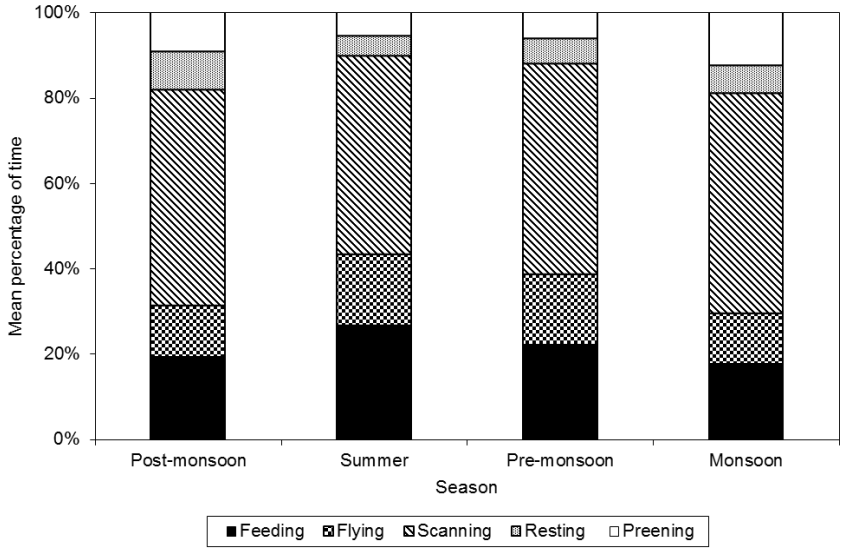
A comparison of the magnitude of each activity among the years was performed using the t-test, the Kruskal-Wallis (H) test was used to compare each activity among the seasons and the habitats, and the Chi-square (χ^2) test was used to compare each activity among the time blocks. For computation and analysis, MINITAB (Minitab Inc. 2006, Pennsylvania, USA) was used, and the results of those analyses were interpreted using standard statistical procedures. The results are reported as significant if they are associated with a value of $p<0.05$.

RESULTS

Overall, scanning was the most important diurnal activity of the Small Bee-eaters (mean±SD: 52.5± 8.41%), followed by feeding (21.3±4.35%), flying (13.3±6.08%), resting (8.8±4.55%) and preening (4.1±3.27%). The diurnal activity patterns exhibited significant annual, seasonal and habitat differences. Scanning was the predominant activity throughout the year, and it was similar in both years ($t=5.07$, $p>0.05$), with an average of 51.7±6.55% in 2005 and 49.5±9.64% in 2006. In 2005, scanning activity differed among the seasons ($H=86.5$, $p<0.05$), with the maximum time spent of 54% during monsoon (Fig. 1); however, in 2006, the Small Bee-eaters spent a similar amount of time among seasons ($H=4.7$, $p>0.05$). Scanning differed among the time blocks ($\chi^2=114.3$, $p<0.05$); in general, the Small Bee-eaters spent more time scanning in the 0900–1200 hr time block (55.2±11.67%) than in the other time blocks (Fig. 2). The Small Bee-eaters spent more time scanning in social forests (53.7±9.31%) than in other habitats (Fig. 3), but scanning was statistically similar in all habitats ($H=7.5$, $p>0.05$).



(a) 2005



(b) 2006

Figure 1: Seasonal variations (within years) in the mean percentage time spent on various activities by the Small Bee-eater, Southern India.

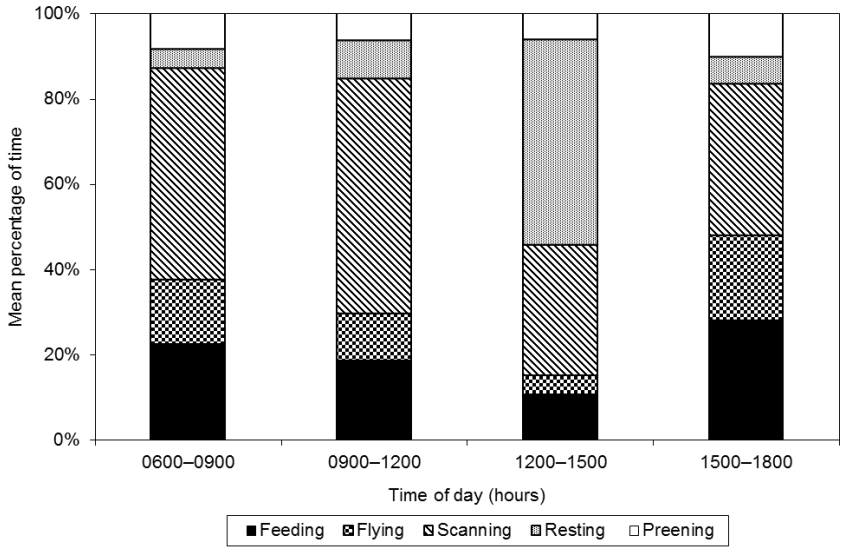


Figure 2: Mean percentage of time spent on different activities by the Small Bee-eater in different times of day (years, seasons and habitats pooled).

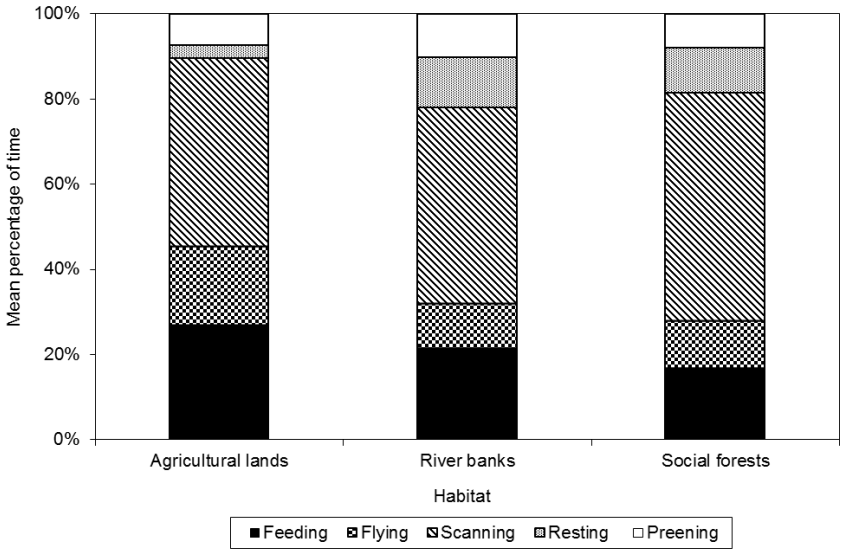


Figure 3: Mean percentage of time spent on various activities by the Small Bee-eater among habitats (years, seasons and time blocks pooled).

Diurnal time spent on feeding activity varied among the years ($t=1.24$, $p<0.05$), with a maximum of 21.3±4.34% in 2006. The percentage of time spent on feeding varied among the seasons within the years ($H=138.6$, $p<0.05$), and in

both years, the birds spent more time feeding in summer (27.8±6.25% in 2005 and 26.8±4.34% in 2006) than in other seasons (Fig. 1). Feeding activity differed among times of day (χ^2=178.5, p<0.05), being generally higher in the morning (22.5±7.23%) and evening (28.0±5.64%) time blocks (Fig. 2). Time allocated to feeding activity varied significantly according to the type of habitat (H=68.4, p<0.05) and was higher in agricultural lands (26.8±10.54%) than in river banks and social forests (Fig. 3).

The time spent flying exhibited similar results, with an average of 15.4±3.88% during 2005 and 13.1±6.20% during 2006. The time spent flying did not vary among seasons within the years (H=10.4, p>0.05); the birds usually spent more time flying during the summer of both years (20.1±6.50% and 16.6±5.23%) (Fig. 1). Flying activity varied among the time blocks of the day (χ^2=131.2, p<0.05) and always peaked (20.1±6.40%) during the late evening (Fig. 2). Flying activity also differed among habitats (H=127.5, p<0.05), being minimal in social forests (11.3±8.32%) and reaching a maximum in agricultural lands (18.6±6.15%) (Fig. 3).

Resting activity varied between years (t=1.16, p<0.05), being lower in 2005 (4.5±2.55%) and higher in 2006 (6.7±3.47%). The time allocated to this activity did not change among the seasons within the years (H=5.87, p>0.05); in both years, birds spent more time resting post-monsoon (6.3±1.65% in 2005 and 8.9±2.5%2 in 2006) (Fig. 1). No significant differences were found in the mean duration of resting activity among the time blocks of the day (χ^2=26.4, p>0.05). Resting activity peaked during midday (48.2±18.24%), being higher than in any of the other time blocks (Fig. 2). The percentage of time spent resting differed among the habitats (H=165.2, p<0.05), being highest in river banks (11.8±3.41%) and lowest in agricultural lands (3.1±2.01%) (Fig. 3).

The daily pattern of preening differed among years (t =1.28, p<0.05) and occupied a greater percentage of time in 2005 (9.4±3.16%) than in 2006 (6.8±1.58%). The time spent on this activity was similar among the seasons (H=8.4, p>0.05), and the birds spent more time preening during the monsoons of 2005 (10.3±2.84%) and 2006 (12.4±1.20%) (Fig. 1). Preening activities varied among time blocks of the day (χ^2=64.3, p<0.05), reaching a maximum at the late evening (10.2±5.59%) and a minimum at midday (6.1±3.45%) (Fig. 2). Preening activities occurred similarly in all habitats (H=4.62, p>0.05), and it peaked at the river banks (10.2±5.44%) (Fig. 3).

DISCUSSION

Scanning was the main diurnal activity for Small Bee-eaters, accounting for more than half (52.5%) of their actions because of their 'sit-and-wait' predatory nature (Ettinger & King 1980; Sivakumaran & Thiyagesan 2003; Ali *et al*. 2010a, b; Asokan *et al*. 2010a). During our study, the birds mostly perched on electric power lines in agricultural lands, shrubby vegetation in river banks and small trees in social forests when searching/scanning for insect prey (Asokan & Ali 2010). Scanning activity was higher in the monsoon and post-monsoon periods and was relatively lower in the summer of the year. This difference may be due to

the northeast monsoon rainfall; during this period, all the habitats were generally wet in nature, which can affect the insect prey distribution. In the post-monsoon, cold temperatures might be expected to force Small Bee-eaters to devote more time to scanning, while the reverse might be true during the summer. The amount of time spent on scanning among time blocks and habitats may be inversely correlated to the insect availability. When insects are abundant, the birds spend less time on scanning; when insects are in short supply, the reverse is true (Ali *et al*. 2010a).

The Small Bee-eater exhibited a typical bimodal feeding pattern: one peak during the morning (0600–0900 hrs) and another peak during the evening (1500–1800 hrs). Many species of birds are known to exhibit feeding maxima early in the morning and late in the evening (Natarajan 1991; Evers 1994; Ramachandran 1998; Rodway 1998; Sivakumaran & Thiyagesan 2003; Ali *et al*. 2010a, b; Asokan *et al*. 2010a; Aissauoi et al. 2011). The increased feeding at the beginning of the day may due to the start of their day-to-day activities, which have high energy requirements; the feeding peak at the end of the day may reflect the overnight energy requirements of the birds (Kelly 1998). The differences recorded in seasonal feeding activity indicate that the birds fed more often during summer and less during monsoon. In the study area, insect prey resources were abundant during the summer (Asokan *et al*. 2003). Small Bee-eaters fed on a variety of insect groups, exclusively beetles, grasshoppers, bees, butterflies and dragonflies from the study habitats (Asokan *et al*. 2009). Feeding activity was greater in the agricultural lands because the insect prey spectrum is wider. The till, plant, harvest and fallow cycle of 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 in other habitats may reflect not only lower insect availability but also avian predatory pressure, inter-specific competitions and human disturbances (Ali *et al*. 2010a, b; Asokan *et al*. 2010a).

In general, the peaks in flying activity were similar to the peaks in feeding activity in all time blocks, seasons and habitats. Generally, flight occurs due to prey capture and movement from one location to another. Disturbances such as human activities and inter- and intra-specific competition are the primary causes of flight activity among Small Bee-eaters.

Resting is a major midday activity of Small Bee-eaters; they typically rest in densely shaded trees and shrubs. The birds take a complete rest when the temperature reaches its daily maximum (e.g., from 1300–1400 hrs); subsequently, they slowly restart their activities. Tamisier (1976) suggested that the increase in resting during midday was a mechanism to minimise the heat load on a bird subject to high environmental temperatures. Previous studies on the time activity patterns of birds (Verbeek 1972; Quinlan & Baldassarre 1984; Losito *et al*. 1990; Lee 1997; Martinez 2000; Ali *et al*. 2010a, b; Asokan *et al*. 2010a) have revealed similar patterns of resting during midday.

Preening occupied a small portion of the time budget and was usually performed in early morning (after leaving from roost sites) and late evening (before entering to roost sites). The wings, breast and back were the body parts most often preened by Small Bee-eaters, followed by the tail, neck, rump and

feet. The most frequent comfort activities were bill scratching, feather shaking and wing flapping. Many bird species have been recorded spending time on these activities (Khera & Kalsi 1986, Natarajan 1991; Ramachandran 1998; Martinez 2000; Muzaffar 2004; Ali *et al*. 2010a, b; Asokan *et al*. 2010a).

The present study provided detailed information on the diurnal activity patterns of the Small Bee-eater, which may be useful in environmental monitoring, the evaluation of habitat suitability, and population management (Evers 1994; Hamilton *et al*. 2002; Jonsson & Afton 2006; Chen *et al.* 2008). Several factors, such as prey availability, environmental factors, and anthropogenic disturbances, are affected by the diurnal activity of birds (Gibson 1978; Mckinney & Mcwiliams 2005; Chen *et al*. 2008). However, further investigation is required to understand the effect of these factors on the diurnal activity patterns of the Small Bee-eater due to its potential role as a biological pest control agent against agricultural insect pests (Asokan 1998; Asokan *et al*. 2009). In the present study, we did not examine the effects of age and sex on the activity of Small Bee-eaters, despite the fact that differences in activity exist among age and sex classes in birds (Jónsson & Afton 2009). Future studies will clarify the differences in activity among the age and sex classes of Small Bee-eaters.

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