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Breeding and foraging ecology of nesting blue tailed bee-eater, *Merops philippinus* in Kannur district, Kerala, India

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ABSTRACT

Blue tailed bee-eater (*Merops philippinus)* is a colony breeding, summer migrant species that excavates nest burrows and forages mainly on airborne insects. We assessed breeding and foraging ecology of blue tailed bee-eater colonies by analysing food remains from pellets and through direct observation. The blue tailed bee-eaters established their breeding colonies in sandy and sandy clay loam having thin vegetation and breeding took place during the rainy season (May to August). They preyed on a wide range of species of insects with more than 90% belonging to Odonata and Coleoptera. Orthopterans were the least exploited prey items. Significant variations in prey consumption between months were also noticed. Odonates and lepidopterans were consumed more in July and August. Consumption of all other prey categories was constant in both months. It is concluded that the blue tailed bee-eater may play an important role in this ecosystem as it can enhance biodiversity through its burrowing and nesting activity and its potential regulation of insect population.

KEYWORDS
Blue tailed bee-eater, Breeding, Foraging, Ecology, Kankol.

INTRODUCTION

Breeding in birds is associated with specific habitats, presumably because of an evolved behaviour to select habitats that provide necessary resources for reproduction and survival (Brown, 1969; Salewski et al. 2007). The various biotic and abiotic factors which are controlling nesting success include food, foraging space, predators, parasites, or competitors and favourable microclimates. For insectivorous birds, availability of nesting and foraging sites varies widely from habitat to habitat and thereby influencing the fitness and survival of individuals. Individuals forage in suitable habitats, where probability of survival is higher (Broughton et al. 2012). Nest-site and substrate availability are important determinants to the size and distribution of some cavity nesting species (Potts et al. 2005). Many species that excavate burrows in soil often nest colonially and the availability of suitable nest sites influences the density of breeding birds. Some ecological correlates of nest site suitability for burrowing birds include particle size or composition of soil, penetrability of soil, and vegetation cover near the nest sites (Wang et al. 2009).

Blue tailed bee-eaters are cavity nesters and like other bee-eater species, they excavate burrows in sparsely vegetated sandy soils (Yuan et al. 2006) and their nest site choice influences the likelihood of successful reproduction due to both abiotic (Block and Brennan, 1993) and biotic environmental factors (Martin, 1993; Forsman et al. 1998). Ecological specialization in terms of prey preferences has been noted in blue tailed bee-eaters and they are specialist predators that feed exclusively upon flying insects especially, hymenopterans (Fry, 1969). Recent studies showed that number of migrating blue tailed bee-eaters has reduced in certain regions of eastern and southern Asian countries due to human pressures on natural habitats (Yuan et al. 2006). For a typical diet specialist species like blue tailed bee-eater, strong dependence on a few specific resources, makes more susceptible while facing potential changes in the resource availability. Thus, if species specific levels of specialization can be fully understood, it can be useful for the conservation purposes. Despite the extensive literature available on cavity-nesting species, a few studies have addressed the breeding and feeding ecology of bee-eater species (Burt, 2002; Goffova et al. 2021). The breeding and foraging ecology of nesting colony of blue tailed bee-eater, *M. philippinus* in the Kankol Village of Kannur District, Kerala has been assessed in this study. This is the only known breeding site of this species, a species that is otherwise known to be a winter visitor to the state in Kerala (Shashikumar et al. 2011). Kankol region with dune soils (sandy loam and sandy clay loam) and terrains, are major breeding habitats for blue tailed bee-eaters. They are being lost rapidly because of urbanization and pollution and these anthropogenic interferences can be extensive overtime and thus, efficient management and conservation policies are required in such ecosystems.

MATERIALS AND METHODS

The study was conducted at the Kankol village (12.10°N, 75.19°E) in the Kannur district, Kerala, India from March 2015 to September 2015. Kankol has a tropical monsoon climate. Mean minimum and maximum temperatures throughout the breeding season during the study were 18 and 26 ^{0}C, respectively. Mean annual rainfall was approximately 3300 mm. Through interviews with residents and intensive surveys at the beginning of breeding season, we identified bee-eater colonies that were active in four different sites of the Kankol village. We selected four different sites which included Karimkuzhi, Kanakol 110 KV power station, Kankol Siva temple ground and Kankol Dr. House (Figure 1). For each site, six plots were randomly selected. Each plot border (25x25 m grid) was placed with small plastic flags to facilitate census and nest monitoring. For each site, we recorded the colony location, number of bee-eaters, number of active nest cavities (nests were considered active when they contained at least one egg), burrow depth, diameter of the burrow opening, number of eggs in the nest cavity, and nest predation inside the plots.

Soil sampling and Testing

We collected approximately 500g of soil (three samples each from three plots from each site) near nest cavities (sandy loam and sandy clay loam) at a depth of 30 cm. Soil samples (N=12 samples) were sealed in plastic bags and transported to the laboratory for further analysis. Samples were analyzed in the district soil testing laboratory, Karimbam, Kannur, Kerala. The following tests were conducted on each sample: pH, TSS, EC (mhos/cm), organic carbon (%), phosphorus (kg/ha) and potassium (kg/ha).

Pellet analysis and Identification

Pellets are the mass of undigested parts of the food that birds occasionally regurgitate. The flocks of the blue tailed bee-eater foraging in the study sites were monitored with binoculars and filmed using a video camera. One foraging bird from each site was used to determine the food taken. The regurgitated pellets were collected from all the study sites and following collection, each specimen was tagged with unique identification number and placed in labeled bottles filled with 70% ethyl alcohol. The pellets were cleaned and sun dried. Identifiable prey remains were sorted under stereo-zoom binocular microscope. The pellets mainly consisted of heads and wings or fragments of insect prey items. Identification of insects were made with the help of entomologists at ZSI, Calicut, Kerala.

Site 1- Karimkuzhi

Site 2- Kankol Substation

Site 3- Kankol Siva Temple Ground

Site 4- Doctor's House, Konkol

Figure 1. Study sites.

Statistical Analysis

All means are reported as ± SD. Pearson's correlation was performed to analyze whether the number of birds decline with the number of nesting sites across all sites. The feeding item data was converted into percentage before analyses. A χ^2 test of multiple proportions was conducted to compare the percentage spent on different food items by blue tailed bee-eater. Alpha was kept at 0.05. Statistical analyses were done using an online free website statstodo.com.

RESULTS

Breeding Ecology

Blue tailed bee-eaters established their breeding colonies in sandy and sandy clay loam having thin vegetation. Breeding took place during the rainy season (May to August).All soil types were highly acidic with a pH of 5.4, TSS EC (0.02 mhos/cm), organic carbon (0.488%), phosphorus (75.84 kg/ha) and potassium (58.24 kg/ha). The average length of the excavated nesting tunnel was 1.81m± 0.09 (N=40). The average diameter of the nest was 8.81 cm ± 0.98. The mean clutch size was 3 ± 1.15 (range 2-5). Nest predators included crows (N = 7) and snakes (N = 4). There were occasional human disturbances in all the nesting sites of the study area. The largest number of breeding individuals was noted at Kankol Power station site whereas lowest number was found in the Kankol sandy site (Figure 3). The total number of blue tailed bee-eater varies in each month considerably with maximum number of birds in May and June and then declining in July and August. The number of active nests and number of birds positively correlated and the number of active nests declined with the number of birds (Pearson's correlation: Pearson's r=0.88, N=134) (Figures 3 and 4).

Figure 2. Blue tailed bee-eaters in their breeding site.

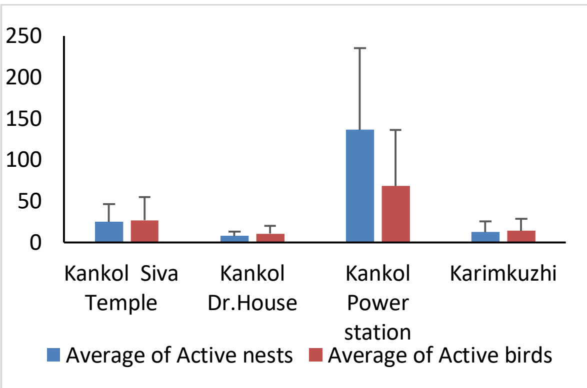

Figure 3. Mean ± SD of active nests and birds at different study sites

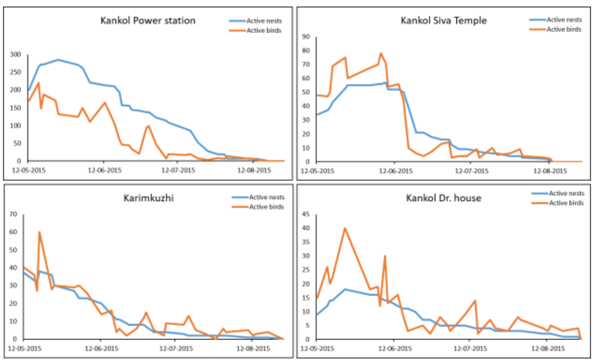

Figure 4. A comparison between number of active nests and active birds at different time periods across study sites

Foraging Ecology

Odonata (15 species) was the best represented arthropod taxon in the diet of blue tailed bee-eater followed by Lepidoptera (10 species), Hymenoptera (five species), Coleoptera (one species) and Orthoptera (one species) (χ^2 test of multiple proportions: χ^2=404.1, df=4, P<0.001; Fig). The predominant prey species were dragonflies belonging to the family, Libellulidae (> 95% of total Odonata prey items) (Figure 5). The other species of odonates preyed upon were Aeshinidae, Chlorocyphidae and Macromiedae. Lepidopterans constituted the second most frequent prey (6% of total prey items). Among lepidopterans the families Papilionidae, and Nymphalidae together formed about 30% of their diet, followed by Lycaenidae (20%), and Hespiriidae (20%) (Figure 6). Hymenopterans were also noticed in the diet. Of these, *Apisdorsata*, *Xylocopaviolacea*, *Apiscerana* and *Bombus* sp. were recorded from the family Apidae and *Campsomeriella collaris* from the family Scolidae. Coleoptera and Orthoptera were clearly the least exploited prey items among the arthropods (constituted 0.6 and 0.1 % of the total prey items respectively). Only a single species of Coleoptera (*Oryctesrhinoceros*) from the family, Scarabaeidae was obtained. A single species of grasshopper was identified from the diet of bee-eater and it belonged to the family Acrididae.

Significant variations in prey consumption between months were found. Odonata and Lepidoptera were consumed more in July and August, and Coleóptera, which was consumed less during these months. Consumption of all other prey categories was constant in both months. However, among Hymenoptera, honeybees were less consumed in July.

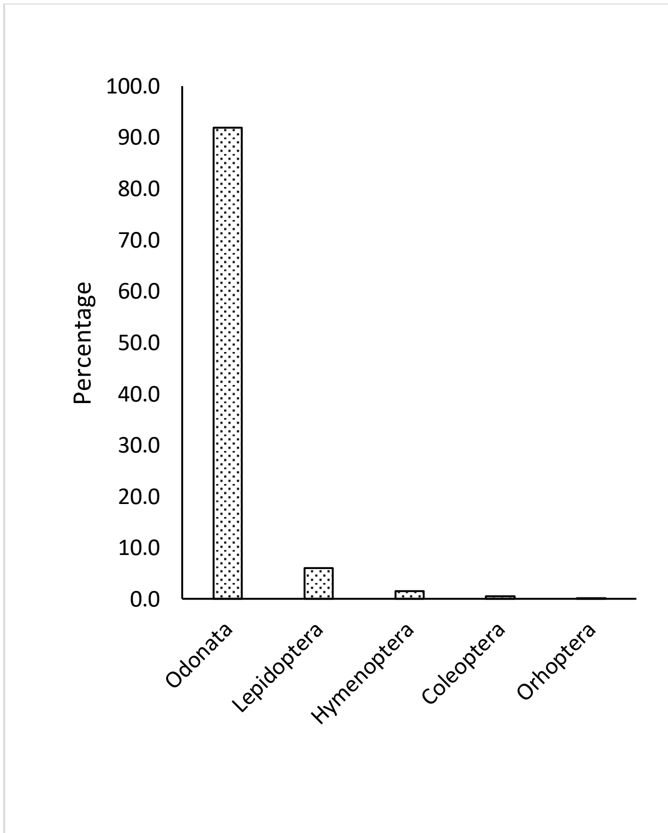

Figure 5. Proportions of main prey groups in the diet of the blue tailed bee-eater.

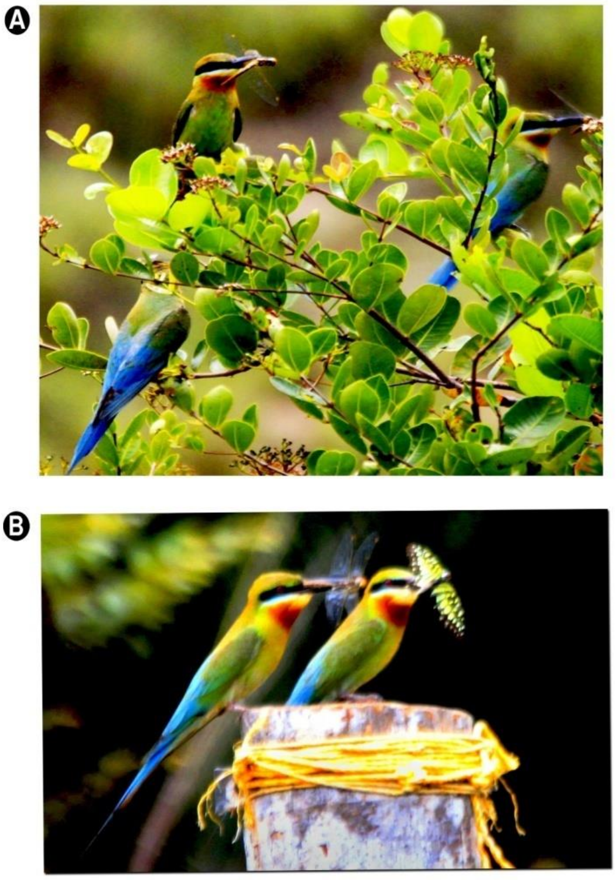

Figure 6. Diet composition of blue tailed bee-eater A: *Merops philippinus* devouring a dragonfly species, *Pantala flavescens*.B: *Merops philippinus* eating a butterfly species, *Graphium agamemnon*

DISCUSSION

The results of the present study indicated that blue-tailed bee-eater colonies constructed nests in sandy and sandy clay loam. Previously, some earlier studies have also reported that bee-eaters prefer sandy substratum for nest construction (White et al. 1978; Kossenko and Fry, 1998; Schmidt and Branch, 2005; Yuan, 2006). They preferred sandy loam and sandy clay loam because such soils had lower soil pressure, density and moisture. Apparently, sandy loams may provide better drainage and ventilation for nest cavities. (White et al. 1978). High porosity and better ventilation are important to diffuse gases in nest tunnels to maintain a tolerable level of O_2 and CO_2 inside the cavities (White et al. 1978).

We found that the average length of the excavated nesting tunnel was 1.81m and the nest entrance had a mean diameter 8.81 ± 0.98 cm. These measurements are more or less like those reported by Ali and Ripley (1983), Fry and Fry (1992), Asokan (1995) and Asokan et al. (2009).

In this study, blue-tailed bee-eaters avoided dense vegetation and preferred thin vegetation to place nest cavities and for foraging activities. Such types of finding also have been reported by White et al. (1978), Emlen et al. (1991), Kossenko and Fry (1998) and Boland (2004). It seems that the dense vegetation might interfere with the movement and foraging efficiency of the birds. The results of this study also showed that the presence of bee-eaters may also be associated with the presence of trees and grasses in the study area. This might be due to the fact that trees and grasses attract diverse insects and provide suitable foraging surfaces and shelters for the bird species. Rotenberry (1985) and Block and Brennan (1999) reported that the vegetation structure and floristic composition were the key factors that affected the habitat selection of birds. Microclimatic factors like temperature, rainfall, relative humidity, and microhabitat factors such as vegetation cover had played major roles in the distribution of prey and bird species in various ecosystems (Yates et al. 1993; Zharikov and Skilleter, 2002). Karr and Freemark (1983) documented the importance of microclimate as a factor in determining avian "physiological comfort." Extremes in microclimate may have adverse effects on birds and their reproductive fitness (Walsberg, 1985; Wachob, 1996). Feeding in open areas where the incoming solar radiation and air temperature are greater than the adjacent vegetated area (Chen et al. 1993) energetically reduces foraging costs (Dewoskin, 1980). Additionally, predation (primarily by snakes) is a constant threat to successful reproduction in this species and reduced vegetation at the colony probably facilitates detection of predators and increases the effectiveness of mobbing behaviour.

Strong preferences were observed by blue tailed bee-eaters for the arthropod taxa; adult blue-tailed bee-eater had an airborne insect prey spectrum and the mean proportion of Odonata in the diet was 91.8 %, compared with a mean proportion of Hymenoptera of 1.5 %; Coleoptera and Orthoptera were the least exploited arthropods. A large proportion of Odonata and Hymenoptera in the diet of bee-eaters were reported in the studies of Fry (1981), Kossenko and Fry (1998) and Arbeiter et al (2014). Generally, bee-eaters do not specialise solely on hymenopterans, rather hunt all large aerial insects opportunistically (Fry, 1984). In the current study, dragonflies were consumed in highest quantities. Aerial insectivorous birds depend highly on favourable weather conditions for successful foraging because flight activity of insects is constrained by daily weather (Arbeiter et al 2014). The availability of certain prey items is mainly affected by insect phenology and weather conditions (Gruebler et al. 2008). Additionally, the presence of certain insect orders in the diet of blue tailed bee-eaters might be influenced by local diversity of habitats, because plant species richness, complexity of vegetation and presence of water bodies could generally increase the abundance of insects (Gruebler et al. 2008; Arbeiter et al 2014). In our study, the surroundings of the colony were characterised by agricultural lands with small ponds, which may provide potential habitats for various insects and supply wide spectrum of prey items including a high abundance of dragonflies. The availability and exploitation of food resources are crucial to many aspects of avian ecology, and it is increasingly important that we understand their impact on bird community ecology and organization.

CONCLUSION

Present study is the first one in Kerala which has explored the breeding and foraging ecology of blue tailed bee-eaters. Moreover, our study focused on the single potential breeding ground of the blue tailed bee-eaters in Kerala, Kankol. Being the only site recognized from Kerala, it throws light on the conservation significance of Kankol. In depth study is required to explore the underlying mechanism of the ecology and behaviour of blue tailed bee-eaters so as to formulate conservation management strategies.

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