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COMMUNICATION

FORAGING AND ROOSTING ECOLOGY OF THE LESSER DOG-FACED FRUIT BAT *CYNOPTERUS BRACHYOTIS* (MAMMALIA: CHIROPTERA: PTEROPODIDAE) IN SOUTHERN INDIA

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FORAGING AND ROOSTING ECOLOGY OF THE LESSER DOG-FACED FRUIT BAT *CYNOPTERUS BRACHYOTIS* (MAMMALIA: CHIROPTERA: PTEROPODIDAE) IN SOUTHERN INDIA

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Abstract: The Lesser Dog-faced Fruit Bat *Cynopterus brachyotis* was found at higher elevations but since there is a paucity of reports on its distribution and habitat selection, an inventory was made at four locations in the Eastern and Western Ghats of southern India where the elevation ranged from 200–1,500 m. The *C. brachyotis* roosts were distributed between 600–1,500 m. Day roosts were found at an elevation of about 1,000m in Sirumalai and Yercaud Hill stations. Mist-netting studies, however, revealed that *C. brachyotis* was widely distributed at different elevations ranging from 600–1,500 m. Moreover, through a radio-telemetry study, we determined that the males foraged at shorter distances from the day roost, whereas the females commuted longer distances and used more than one foraging area. The male bats' time of emergence is significantly less than females; in addition, males frequently return to their day-roost and made several short foraging flights spaced randomly throughout the night. These observations suggest that some type of territoriality is associated with their roost, which appears to be the basis of social organization in *C. brachyotis*. Overall, this study provides detailed information about the foraging and roosting ecology of *C. brachyotis* in southern India.

Keywords: *Cynopterus brachyotis*, Eastern Ghats, Fruit Bat, habitat use, mist netting, radio-telemetry, Western Ghats.

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Author Contribution: Study design (TK and SK); field work, data collection and analysis (TK); photography and manuscript writing (TK and SK), manuscript correction and revision (TK).

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DEPARTMENT OF BIOTECHNOLOGY
Ministry of Science & Technology

INTRODUCTION

The Lesser Dog-faced Fruit Bat *Cynopterus brachyotis* is a group-living, frugivorous, yinpterochiropteran bat, distributed throughout Southeast Asia (Corbet & Hill 1992; Bates & Harrison 1997; Simmons 2015). It is commonly found at higher elevations of the tropical evergreen forests (Lim 1966; Francis 1994; Balasingh et al. 1999). In India, it is reported from a few pockets in the Western and Eastern Ghats (Balasingh et al. 1999). The behaviours of *C. brachyotis* such as tent construction (Kunz et al. 1994; Tan et al. 1997), pollination and seed dispersal (Phua & Corlett 1989), food habits (Tan et al. 1998) and hind limb motion (Cheney et al. 2014) were studied in detail and most of the studies had been carried out in the Southeast Asian countries like Myanmar, Thailand (Bumrungsri & Racey 2007; Bumrungsri et al. 2007), peninsular Malaysia and the Philippines (Lim 1966; Francis 1994; Zubaid 1994). The available data suggest that this is one of the poorly studied species in the Indian subcontinent. Especially, knowledge about distribution, abundance and habitat selection in southern India is still rather incomplete and also little is known about their dispersal patterns, sex ratio, breeding behaviour and social structure. Moreover, this species is dwindling due to increased human interference so that traditional roosts have been drastically reduced as a consequence of tree felling and there is a need for a greater understanding of the species' occurrence and roosting habits. Therefore, the main aim of the present study was to evaluate the foraging and roosting ecology of the Lesser Dog-faced Fruit Bat *C. brachyotis* in southern India.

MATERIALS AND METHODS

Study area

We conducted this study on a monthly basis for a total of 24 months from April 2007 to March 2009 in four different hill regions: Sirumalai (10.1942°N & 77.9967°E), Kodaikkanal (10.2381°N & 77.4892°E), Megamalai (High Wavy Mountains; 9.6461°N & 77.4013°E), and Yercaud (11.7753°N & 78.2093°E; Fig. 1). The study was carried out at different elevations ranging between 200m and 1,500m. In addition, the day roosts of *C. brachyotis* in Sirumalai and Yercaud hill regions were surveyed during October and November 2015 and March and April 2016.

Sampling method (Mist-netting)

Bats were captured using nylon mist nets of 9m

x 2.6m with a mesh size of 38mm (Avinet-Dryden, New York, USA) from different altitudes of the above mentioned study areas (Image 1). Mist netting was done from a height of 200–1,500 m. At each altitude, we mainly concentrated on three locations, which had most roosting resources and high food resources for bats. Each location was measured approximately 0.1km in diameter and separated by a minimum of 1km from the closest location. The maximum distance between the locations was about 5km. Since, forest fragments were small and limited to areas too steep and inaccessible for coffee, tea and banana cultivation, it was impossible to find distant capture locations within fragments in four different hill regions. Every month mist netting was carried over a period of nearly 24 months. Mist netting was carried out for 24 nights per elevation (8 nights per location) totaling 168 nights (2,016 night hours) for seven elevations (200–400; 400–600; 600–800; 800–1,000; 1,000–1,200; 1,200–1,400; 1,400–1,500 m) from dusk to dawn. The mist nets were placed away from illuminated areas to avoid visual detection by bats. Mist nets covered a height of up to 4m from the ground. They were erected about half an hour before sunset and removed at 06:00hr. Mist nets were open all night long (12 hours), under different climatic conditions, like new and full moon phases and even during rainy nights. The sampling effort was calculated in net-hours, one net-hour corresponding to one mist net (9x2.6 m, 38mm mesh) opened for one hour [one 9x2.6 m net open for 1h equal to 1 mist-net-hour (mnh)]. Each night, we used one net, resulting in a total sampling effort of 288 net-hours for each elevation, totally 2,016 net-hours for seven elevations in each hill. In order to identify the relative abundance of *C. brachyotis* (excluding recapture) in four different hill regions, we calculated relative capture rates (number of captured individuals/mist net-hour) for each hill station. Bats caught in mist nets were removed immediately with gloved hands and placed in cloth bags (Gaisler 1973). The morphological measurements such as body mass and length of forearm were measured using a spring balance (Avinet-Dryden, USA) and a Vernier caliper, respectively and also for each bat, species, sex, age were identified, marked and released (Elangovan et al. 2003); a large number of bats were captured within a short duration, they were placed in a holding cage to avoid stress. All the captured bats were marked with a color-coded bead necklace. Ten colored beads (5mm) were used for marking the bats with each color denoting a number from 0–9 (Balasingh et al. 1992). We used three beads for each necklace. Thus, all possible sequential arrangements of the beads

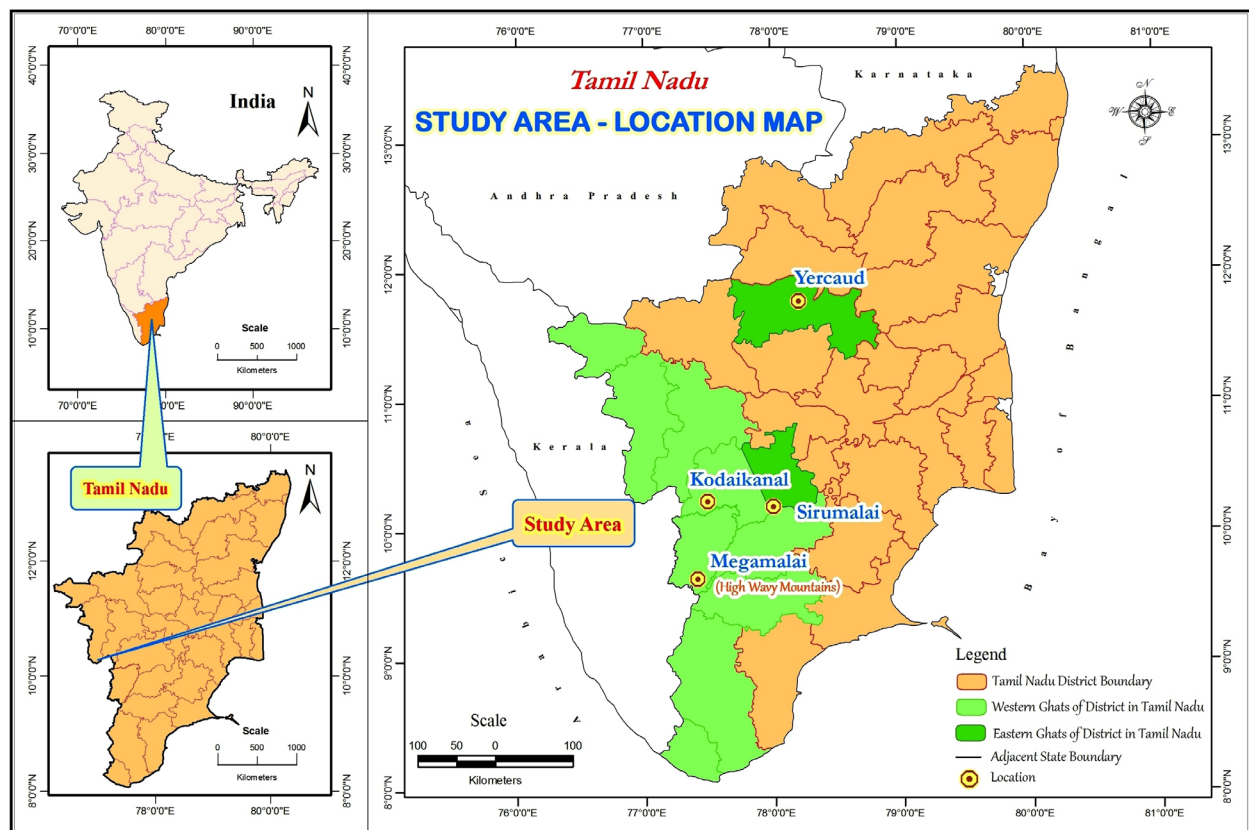


Figure 1. Map shows the location of four different hill regions (study areas) in southern peninsula of India.



Image 1. Closer views of *C. brachyotis* (a & b) captured in the study areas.

provided up to 999 unique tags. The necklace was secured around the bat's neck, by crimping the sleeved copper ring with long-nose pliers. We have used this type of tagging for various studies and have observed no apparent detrimental effects on bats (Gopukumar et al.

2003; 2005; Karuppudurai et al. 2008). After marking, all individuals were released at the site of capture. These markings allowed us to identify individuals and determine their past roosting locations. No bats were injured, killed or retained as specimens during this study.

Radio-telemetry studies

In addition to mark-recapture studies, a radio-telemetry study was conducted during September and October 2008 in Yercaud Hill station. For this study, four bats (2 females and 2 males) of *C. brachyotis* were selected within the study area. The bats were captured at the time of emergence using mist nets and each bat was fitted with a transmitter (Model BD-2, Holohil Systems Ltd., Carp, Ontario, Canada). The weight of the transmitter was 1.5g with a transmission range of 400–500 m, which was mounted over an aluminium collar covered with reflective tape. The reflective tape allowed us to locate the bat within the dense foliage using a torchlight. The transmitter along with the collar was less than 5% of adult body mass. Bats fitted with radio collars were released within 3h of capture, but were not intensely monitored until the following night. Two tracking groups monitored the radio-tagged bat using Merlin receivers and collapsible 3-element Yagi antennae (Customs Electronics, Urbana, Illinois, USA). While, one unit tracked the bat in the foraging area, the other unit stationed near the day roost monitored the bat activity at the roost. In addition, the activity of the bat at the roost was observed using a red torch (>640 nm). We rarely lost radio contact with the focal animal. If radio contact was broken with a moving bat, contact usually was re-established within 20min by walking towards the bearing of disappearance. A change in pulse rate according to the orientation of the antenna allowed us to determine whether the bat was flying or roosting. The constant beep signals were considered as 'rest' and variable singles were considered as 'flying'. We defined foraging time as the period between emergence from the roost at dusk and return to the roost at dawn. 'Foraging bouts' are defined as the period during which a bat flew continuously between leaving the roost and returning to the same roost. The number of foraging bouts and time spent in the day roost during night hours by male and female *C. brachyotis* was analysed by t-tests. Values are expressed as mean \pm SD throughout the text.

RESULTS

Mist-netting studies

Over the course of mist netting survey at four different hills, a total of 362 *C. brachyotis*, were captured (Table 1). Of the 362 *C. brachyotis*, about 41 individuals (11.3%) were recaptured (23 adult females, 11 adult males, five young females, and two young males). Adult females (56.1%) were recaptured more frequently followed by adult males, young females and young males and accounted for 26.8%, 12.2% and 4.9% respectively. In general, more adult females and males were recaptured at nearby elevations but occasionally adult females were recaptured in distant elevations than males. For example, in Kodaikkanal hill station, one tagged adult female was captured at an elevation of 1,400–1,500 m but was originally captured and tagged at an elevation of 800–1,000 m.

Among the four different hills, the Sirumalai hill region accounted for 22.4%, of bats, the Kodaikkanal hill station accounted for 28.2% of bats, the Megamalai (High Wavy Mountains) accounted for 26.2% and Yercaud accounted for 23.2% of the total bats (Table 1). There was no significant difference found among the total number of *C. brachyotis* captured at different elevations in four different hill stations (ANOVA: $F_{3, 24} = 0.08$, $P = 0.97$), and also there was no significant difference among the total *C. brachyotis* mark-recaptured at four different hill stations (ANOVA: $F_{3, 24} = 0.33$, $P = 0.80$). To identify the abundance of *C. brachyotis* (excluding recapture) in four different hill stations, we conducted a total of 2,016 mist-net-hours in each hill station. In Sirumalai Hill station a total of 81 *C. brachyotis* were captured with a capture rate of 0.040 bats per net-hour. In Kodaikkanal Hill station a total of 102 bats were captured, which corresponds to a capture rate of 0.051 bats per net-hour, in Megamalai a total of 95 bats were captured, with a capture rate of 0.047 bats per net-hour and in Yercaud 84 bats were captured, which corresponds to a capture rate of 0.042 bats per net-hour.

Table 1. Total number of *C. brachyotis* and other bat species captured at four different hill stations in southern Western Ghats. Value in parentheses is percentage (%) of bats captured in each species.

Study areas / Bat species	Sirumalai (1,600m)	Kodaikkanal (2,133m)	Megamalai (1,500m)	Yercaud (1,623m)	Total number of bats
<i>C. brachyotis</i>	81 (22.4)	102 (28.2)	95 (26.2)	84 (23.2)	362 (61.3)
<i>C. sphinx</i>	107 (49.1)	86 (39.4)	14 (6.4)	11 (5.0)	218 (38.7)
<i>R. leschenaulti</i>	3 (33.3)	4 (44.4)	2 (22.2)	0 (0.0)	9 (1.5)
<i>M. spasma</i>	0 (0.0)	0 (0.0)	2 (100)	0 (0.0)	2 (0.3)

In addition, a total of 229 bats of another three species were captured. All species captured were common bats (Table 1). Two species of fruit-eating bats, *Cynopterus sphinx* (218), *Rousettus leschenaultii* (9), and one species of insect-eating bat *Megaderma spasma* (2). Our study species *C. brachyotis* accounted for 61.3% of all bats captured. Other three bat species *C. sphinx*, *R. leschenaultii* and *M. spasma*, accounted for 38.7%, 1.5% and 0.3%, respectively. Overall, members of the *C. brachyotis* (61.3%) and *C. sphinx* (38.7%) were captured most frequently (Table 1). There was no significant difference among the total bats captured at four different hill stations (ANOVA: $F_{3,12} = 0.27$, $P = 0.84$).

Distribution, abundance and roosting ecology of *C. brachyotis*

The distribution and abundance of *C. brachyotis* survey was carried out at different elevations starting from 200–1,500 m. More *C. brachyotis* were captured and observed in higher elevation (600–1,500 m; Fig. 2) and stayed only in higher elevations in southern India. In contrast, the *C. sphinx* was captured both in higher and lower elevations but the capture rate was lower in higher elevation and higher in lower elevation. We distinguished *C. brachyotis* from *C. sphinx* on the basis of four morphological characters like forearm length, body mass, ear length and pelage colour (Image 1). The mean forearm length (61.6 ± 1.7 mm) and mean body mass (32.3 ± 2.5 g) of *C. brachyotis* were significantly lower than the mean forearm length (68.5 ± 2.2 mm)

and body mass (47.2 ± 3.8 g) of *C. sphinx* (forearm length of *C. brachyotis* vs. *C. sphinx*; $t = -23.902$, $P < 0.05$; body mass of *C. brachyotis* vs. *C. sphinx*; $t = -19.852$, $P < 0.05$). The mean ear size of *C. brachyotis* (16.9 ± 0.72 mm) was significantly smaller compared with mean ear size of *C. sphinx* (20.2 ± 1.1 mm; $t = -15.041$, $P < 0.05$). The dorsum of *C. brachyotis* is cinnamon brown compared with the darker olive black of *C. sphinx* (Image 1).

The day roosts of *C. brachyotis* were located at an elevation of above 1,000m in Sirumalai and Yercaud hill stations (Image 2). In these study areas, *C. brachyotis* constructed tents in the pepper plant (*Piper nigrum* L.), leaves of banana tree (*Musa acuminata*) and in the cavities of Indian Banyan tree (*Ficus benghalensis*) which were observed. At Yercaud, a day roost consisting of 10 *C. brachyotis* were found in the roof of an abandoned building (Image 2f). Recent direct observation of day-roosts revealed that *C. brachyotis* completely abandon the pepper plant (*P. nigrum* L.) and leaves of banana tree (*M. acuminata*) tents. The cavity of Indian Banyan tree (*F. benghalensis*), however, was still used as a day roost.

Radio-telemetry studies

In the radio-telemetry study, four bats (2 males and 2 females) were radio-tagged in order to estimate the number and type of foraging areas used by *C. brachyotis* (defined as the localities within which bats were found, presumably feeding, during a large proportion of the night) and patterns of nightly behaviour by individual bats. Each locality has different habitats interspersed



Image 2. Variety of day roosts used by *C. brachyotis* in southern Western Ghats (a) Indian Banyan tree (*F. benghalensis*), (b) a closer view of the tree cavity, (c) a group of *C. brachyotis* roosting in the tree hollow, (d) Pepper plant (*P. nigrum* L.), (e) a closer view of bat roost, and (f) a group of *C. brachyotis* roosting in the roof of an abandoned building. © Authors

Table 2. Tracking summary of radio collared male and female bats of *C. brachyotis* in Yercaud Hill region.

Bat code	Observed days	No. of day roosts used	No. of night roosts used	Cause for end of observation
M1	16	1	3	Transmitter recovered
M2	10	1	1	Transmitter loss
F1	5	1	2	Transmitter loss
F2	14	2	1	Bat disappeared

Table 3. Number of foraging areas used by radio tagged bats in the study area. Value in parentheses is distance(s) to foraging areas from the day roosts (km).+ used; - not used

Bate code	No. of Foraging areas					
	1	2	3	4	5	6
M1	+(0.2)	+(0.6)	+(0.9)	+(1.2)	+(2.0)	-(4.0)
M2	+(0.1)	+(0.8)	+(0.4)	+(1.1)	-(2.4)	-(4.5)
F1	-(0.8)	-(1.0)	+(0.5)	+(1.5)	+(2.8)	+(5.2)
F2	-(1.0)	+(1.2)	+(0.8)	-(2.0)	+(3.0)	+(6.0)

with coffee plantations, orange groves, pepper plants and banana trees and the localities are separated from the day roosts by one kilometer. The male (M1 and M2) and female (F1 and F2) bats were successfully tracked for 16, 10, 5 and 14 days respectively and their day roosts were also located successfully (Image 3). The female bat (F2) was roosting in the pepper plant (*P. nigrum* L; Image 3a,b) and the male bat (M1) was roosting in the banana tree (*M. acuminata*; Image 3c). Interestingly, the male bats used a maximum of three night roosts. Conversely, the female bats used a maximum of two night roosts. All the male bats used a single day roost and female bat F1 used a single day roost while female F2 used 2-day roosts (Table 2). The male bat returned to its day roost (modified leaves of banana tree) regularly, however, female bats changed their day roost frequently to either pepper plants and/or a cavity in an Indian banyan tree. The male and female bats used 5 and 6 different foraging areas, respectively (Table 3). The foraging site one was used exclusively by male bats and site 6 was used exclusively by female bats. The male bats foraged ca. 4–4.5 km and the female bats foraged 5–6 km from the day roosts. Female bats travelled longer distances and used more foraging areas (Table 3).

The male and female bats foraged at different areas. Throughout the study, male bats made many visits to its day roosts and thus it spent significantly less time in foraging. There was significant difference in the mean number of foraging bouts/night between male (7.6 ± 1.1) and female (2.2 ± 0.8 , $n=5$ nights) bats ($t = 6.65$, $P < 0.05$;

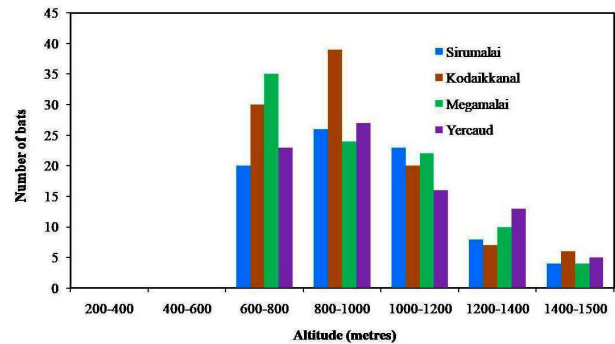
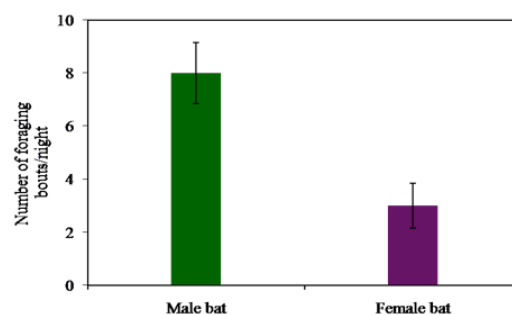
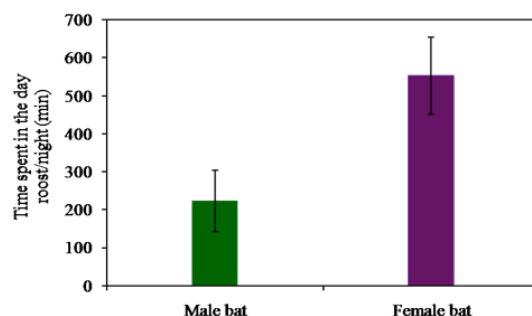
**Figure 2.** Altitudinal variation in the abundance and distribution of *C. brachyotis* in southern Western Ghats. None of the *C. brachyotis* were captured in lower elevations (200–600 m) and more bats were captured only in higher elevations (600–1,500 m).**Figure 3.** Number of foraging bouts by male and female bats/night.**Figure 4.** Time spent in the day roost by male and female bats during night hours.

Fig. 3) and also there was significant difference in the mean time spent in the day roost/night between males (223 ± 80.7 min) and females (554 ± 100.2 min, $n=5$ nights) ($t = 4.97$, $P < 0.05$; Fig. 4).

DISCUSSION

Diversity and richness of *C. brachyotis* in southern India

Our study provides detailed information about the distribution, abundance and number of foraging areas of *C. brachyotis* in peninsular India. Day roosts of *C. brachyotis* were located at an elevation of about 1000m and distributed at different elevations that ranges from 600–1,500 m in all selected hill stations to avoid biotic and abiotic disturbance (Brooke et al. 2000; Baskaran et al. 2016). These observations, suggest that *C. brachyotis* occur at higher elevations in southern India, whereas, in Southeast Asia *C. brachyotis* prefers to stay in the plains (Kunz et al. 1994; Tan et al. 1997). In contrast, the Indian Short-nosed Fruit Bat *C. sphinx* were captured both in higher and lower elevations but the capture rate of *C. sphinx* was lower in the higher elevation. Most fruit bats are known to play a crucial role in reforestation through seed dispersal. Previous studies showed that *C. brachyotis* modified leaves of palm trees to construct tents which were then used as day roosts and/or feeding roosts (Tan et al. 1997). In this study, we observed that *C. brachyotis* modifies the pepper plant, leaves of the banana plant, and also used cavities in the Indian banyan tree as day roosts (TK-personal observation). Our recent day roost observations clearly revealed that modified pepper plant and banana tree roosts were completely abandoned by *C. brachyotis* in Sirumalai and Yercaud hill stations. The reasons for decrease in the bat population and roost sites appear to be increased human interference by way of cultivation. Traditional roosts have been drastically reduced as a consequence of tree felling (TK-personal observation).

Feeding behaviour

Previous studies suggest that the fruit bat *C. brachyotis* feeds on fruits of 54 plant species, leaves of 14 species and the stamens of four species. Its role as a seed disperser has been documented in other Southeast Asian countries (Marshall 1983; Phau & Corlett 1989). In the present study, we observed that *C. brachyotis* mainly feed on several fruits, especially banana, jackfruit, orange and coffee. The feeding roosts were usually within 100m of the fruiting tree. Occasionally fruits were carried too far (2–3 km). In our study areas, the most favoured day-roost in the hills was the pepper plant, which sometimes supported colonies of 10 or more bats. In our field studies, most of the mist-netted bats were *C. brachyotis* flying at 2–5 m from the ground. The foraging pattern was observed indirectly from the rate of capture at every hour from

dusk to dawn by mist netting. The peak foraging activity occurred between 21:30–23:00 hr with a small peak at 04.30–05.30 hr showing a dominant unimodal pattern of foraging activity in *C. brachyotis*. The second small peak cannot be considered as foraging activity as it may represent a return from the foraging areas. Generally, bimodal activity patterns are characteristic of almost all insectivorous species and some fruit eating bats (Fleming 1982; Elangovan et al. 1999; Stephenraj et al. 2010). In contrast, unimodal patterns are dominant among frugivorous and nectarivorous species (Fleming & Heithaus 1986). From our indirect observations, the unimodal pattern of foraging activity was observed in *C. brachyotis*, however, further systematic studies are required to determine the pattern of foraging activity.

Roosting Ecology

Radio-telemetry studies showed that bats left their day roosts shortly after sunset and flew to foraging areas while they began to search for ripe fruits. The harvested fruit is transported to the night roost for consumption. These 'night roosts' might promote digestion and energy conservation, offer retreat from predators, serve as centers for information transfer about the location of fruit patches and facilitate social interaction (Morrison 1978; Kunz 1982; Fleming 1988). Throughout our study one male bat was found to have high night roost fidelity. A banana tree was used as a night roost constantly. The regular travel path exhibited by this bat between its day roost and foraging area may be attributed to the constancy of resource availability. Such trap-lining behaviour (repeated sequential visits to a series of feeding or foraging locations) minimizes commuting search distance and energy cost. But the other tagged bats of both sexes used more than one night roost. High risk of predation may be attributed for the usage of more night roosts. It seems clear that male *C. brachyotis* restrict their foraging areas close to the day roost, whereas, females commute longer distances and utilized several foraging areas. Since, the male is involved in tent construction, harem formation, and defense, a foraging area a short distance away would facilitate harem defense strategies near the day roost (Fleming 1988). These observations of short distance foraging flights of males are consistent with the earlier reports on the activity of harem males in *C. sphinx*, *Artibeus jamaicensis*, *Phyllostomus hastatus*, *Carollia perspicillata*, and *Balionycteris maculata* (Morrison 1978; Fleming 1988; Balasingh et al. 1995; Bhat & Kunz, 1995; Marimuthu et al. 1998; Gopukumar et al. 1999; Hodgkison et al. 2003; Karuppudurai et al. 2008). This



Image 3. Day roosts used by radio-tagged male and female bats of *C. brachyotis* (a) modified Pepper plant (*P. nigrum* L.) roost (long view), (b) a radio collared female bat roosting in the Pepper plant roost (close view), and (c) a radio collared male bat roosting in the leaves of Banana tree (*M. acuminata*) (transmitters and bats are indicated by arrows). © Authors

suggests that some type of territoriality is associated with shelter, which appears to be the basis of social organization of bats (Kunz et al. 1998).

Foraging behaviour of male and female *C. brachyotis*

Female bats travel long distances (ca. 6km). Besides, they change their primary foraging area in an unpredictable fashion as observed in *C. perspicillata* (Kunz 1982). Since not every foraging area contains the same potential food resources, one reason for such unpredictable 'shuttles' might increase dietary diversity. The foraging areas of females are isolated whereas the foraging areas of males are overlapping. Since the day roost of most of the males lie within a rich food patch, overlapping of foraging areas is likely to arise (our unpublished data). The exact reasons why female *C. brachyotis* commute longer distances, spend more time foraging and utilize several foraging areas are not clearly known. One of the reasons for long distance commuting by females might be searching for potential male tent

roosts and to assess the harem male's parental ability. Recent studies reported the importance of female choice especially in highly mobile animals with harem mating systems (Clutton-Brock 1989; McComb 1991). Female *Saccopteryx bilineata* actively select their roosting location and are highly mobile; some females shift roosting territories during the course of a day and some disperse to other colonies (Heckel et al. 1999). In addition, earlier studies in *C. sphinx* reported fluctuations in the harem size on a day-to-day basis, indicating that females periodically shifted their tents (Balasingh et al. 1995; Karuppudurai & Sripathi 2010). Similarly, the polygynous bats *A. jamaicensis* (Ortega et al. 2003), *P. hastatus* (McCracken & Bradbury 1977), *Desmodus rotundus* (Wilkinson 1985), and *S. bilineata* (Heckel et al. 1999) shifted their roosting sites. Our radio-telemetry studies lend support to these observations. In the present study, one female bat used more than one day roost and also shifted her day roosts frequently. Overall, male and female *C. brachyotis* differed in their foraging

areas and behaviour, as it has been shown for many other bat species like *Rousettus aegyptiacus* (Barclay & Jacobs 2011), *Myotis daubentonii* (Ngamprasertwong et al. 2014), and *Nycticeius humeralis* (Istvanko 2015). An extension of molecular genetics techniques to behavioural ecology might help in understanding the behavioural ecology of *C. brachyotis*. For example, how the behavioural phenotypes are controlled by genes, how they interact with other genes, what is the molecular and genetic basis of their allelic variation, and how this variation behaves with respect to the environment.

CONCLUSION

The present study describes the distribution, relative abundance and number of foraging areas of *C. brachyotis* in four different hill stations in the southern Western Ghats. These findings provides additional knowledge of the behavioural ecology of fruit bats in the Western Ghats, southern India in order to improve habitat suitability models, define critical habitat, and direct land management policies. There is little information about this species in the Indian subcontinent especially in the Western Ghats. Hence, this study provides detailed information about the habitat selection of *C. brachyotis* and is useful in bringing out new information about this species and also gives more information about the *altitudinal* preference and plant animal interaction in the forest area. The understanding of habitat selection of *C. brachyotis* can contribute valuable guidelines for proper conservation and management and is also helpful for formulating bat conservation strategies. Further studies, however, are needed to determine the dispersal patterns, sex ratio, mating strategy and genetic diversity of *C. brachyotis* over the long term using behavioural and molecular techniques.

REFERENCES

- Balasingh, J., J. Koilraj & T.H. Kunz (1995). Tent construction by the short-nosed fruit bat *Cynopterus sphinx* (Chiroptera: Pteropodidae) in southern India. *Ethology* 100: 210–229; <http://doi.org/10.1111/j.1439-0310.1995.tb00326.x>
- Balasingh, J., J. Ronald P. Thiruchenthil Nathan & S.S. Isaac (1999). Occurrence of *Cynopterus brachyotis* (Chiroptera: Pteropodidae) in Kalakad Mundanthurai tiger Reserve, Southern India. *Current Science* 76: 1542.
- Balasingh, J., S.S. Isaac & R. Subbaraj (1992). A convenient device for tagging bats in the field. *Bat Research News* 33: 6.
- Barclay, R.M.R & D.D. Jacobs (2011). Differences in the foraging behaviour of male and female Egyptian fruit bats (*Rousettus aegyptiacus*). *Canadian Journal of Zoology* 89: 466–473; <http://doi.org/10.1139/z11-013>
- Baskaran, S., A. Rathinakumar, J. Maruthupandian, P. Kaliraj & G. Marimuthu (2016). The effect of daytime rain on the Indian flying fox *Pteropus giganteus*. *Journal of Threatened Taxa* 8(2): 8499–8502; <http://doi.org/10.11609/jott.1959.8.2.8499-8502>
- Bates, P.J.J & D.L. Harrison (1997). *Bats of the Indian Subcontinent*. Harrison Zoological Museum Press, England, 258pp.
- Brooke, A.P., C. Solek & A. Tualaulelei (2000). Roosting behaviour of colonial and solitary flying foxes in American Samoa (Chiroptera: Pteropodidae). *Biotropica* 32: 338–350; <http://doi.org/10.1111/j.1744-7429.2000.tb00477.x>
- Bumrungsri, S & P.A. Racey (2007). Resource partitioning in Sympatric *Cynopterus brachyotis* (Muller 1838) and *C. sphinx* (Vahl 1797) (Chiroptera: Pteropodidae) in Lowland Tropical Rain forest, Thailand. *Biotropica* 39: 241–248; <http://doi.org/10.1111/j.1744-7429.2006.00245.x>
- Bumrungsri, S., W. Bumrungsri & P. A. Racey (2007). Reproduction in the short-nosed fruit bat in relation to environmental factors. *Journal of Zoology (London)* 272: 73–81; <http://doi.org/10.1111/j.1469-7998.2006.00245.x>
- Cheney, J.A., D. Ton, N. Konow, D.K. Riskin, K.S. Breuer & S.M. Swartz (2014). Hind limb motion during steady flight of the Lesser Dog-faced Fruit Bat, *Cynopterus brachyotis*. *PLoS ONE* 9: e98093; <http://doi.org/10.1371/journal.pone.0098093>
- Clutton-Brock, T.H. (1989). Female transfer and inbreeding avoidance in social mammals. *Nature* 337: 70–71; <http://doi.org/10.1038/337070a0>
- Corbet, G.B & J.E. Hill (1992). *The Mammals of the Indomalayan Region: A Systematic Review*. Oxford University Press, UK, 243pp.
- Elangovan, V., E.Y.S. Priya, H. Raghuram & G. Marimuthu (2003). Postnatal development in the Short-nosed Fruit Bat (*Cynopterus sphinx*): growth rate and age estimation. *Acta Chiropterologica* 5: 107–116; <http://doi.org/10.3161/001.005.0110>
- Elangovan, V., G. Marimuthu & T.H. Kunz (1999). Temporal patterns of individual and group foraging behavior in the Short-nosed Fruit Bat, *Cynopterus sphinx*, in South India. *Journal of Tropical Ecology* 15: 681–687; <http://doi.org/10.1017/S0266467499001091>
- Fleming, T.H. (1982). Foraging strategies of plant-visiting bats, pp. 287–325. In: Kunz, T.H. (ed.). *Ecology of Bats*. Plenum Press, New York.
- Fleming, T.H. (1988). The short-tailed fruit bat: a study in plant-animal interactions. University of Chicago Press, Chicago, 365pp.
- Fleming, T.H & E.R. Heithaus (1986). Seasonal foraging behavior of the frugivorous bat *Carollia perspicillata*. *Journal of Mammalogy* 67: 660–671; <http://doi.org/10.2307/1381127>
- Francis, C.M. (1994). Vertical stratification of fruit bats (Pteropodidae) in lowland dipterocarp rainforest in Malaysia. *Journal of Tropical Ecology* 6: 421–431; <http://doi.org/10.1017/S0266467400008191>
- Gaisler, J. (1973). Netting as possible approach to study bat activity. *Periodicum Biologorum* 75: 129–134.
- Gopukumar, N., T. Karuppudurai & D.P. Swami Doss (2005). Dispersal patterns of the Short-nosed Fruit Bat *Cynopterus sphinx* (Chiroptera: Pteropodidae). *Mammalian Biology* 70: 122–125; <http://doi.org/10.1016/j.mambio.2004.10.001>
- Gopukumar, N., T. Karuppudurai, P.T. Nathan, K. Sripathi, G. Arivarignan & J. Balasingh (2005). Solitary adult males in a polygynous mating bat (*Cynopterus sphinx*): A forced option or a strategy? *Journal of Mammalogy* 86: 281–286; <http://doi.org/10.1664/BFW-031.1>
- Gopukumar, N., V. Elangovan K. Sripathi, G. Marimuthu & R. Subbaraj (1999). Foraging behaviour of the Indian short-nosed fruit bat *Cynopterus sphinx*. *Zeitschrift für Saugetierkunde* 64: 187–191.
- Heckel, G., G.G. Voigt, F. Mayer & O. von Helversen (1999). Extra harem paternity in the White-lined Bat *Saccopteryx bilineata* (Emballonuridae). *Behaviour* 136: 1173–1185; <http://doi.org/10.1163/156853999501829>
- Hodgkison, R., S.T. Balding, A. Zubaid & T.H. Kunz (2003). Roosting ecology and social organization of the Spotted-winged Fruit Bat, *Balionycteris maculata* (Chiroptera: Pteropodidae), in a Malaysian lowland dipterocarp forest. *Journal of Tropical Ecology* 19: 667–676;

- <http://doi.org/10.1017/S0266467403006060>
- Istivanko, D.R. (2015). Sex-specific foraging habits and roost characteristics of the evening bat (*Nycticeius humeralis*) in an intensively managed forest in north-central Arkansas. MS Dissertation, Arkansas State University, USA, 102pp.
- Karuppudurai, T. & K. Sripathi (2010). Molecular genetic analysis of male alternative strategy and reproductive success in the polygynous mating bat *Cynopterus sphinx*. *Journal of Cell and Animal Biology* 4: 042–050.
- Karuppudurai, T., K. Sripathi, N. Gopukumar, V. Elangovan & G. Arivarignan (2008). Transition of non harem male to harem male status in the Short-nosed Fruit Bat *Cynopterus sphinx*. *Mammalian Biology* 73: 138–146; <http://doi.org/10.1016/j.mambio.2007.02.006>
- Kunz, T.H. (1982). Roosting ecology of bats, pp. 1–50. In: Kunz, T.H. (eds.). *Ecology of Bats*. Plenum Press, New York.
- Kunz, T.H., M.S. Fujita, A.P. Brooke & G.F. McCracken (1994). Convergence in tent architecture and tent-making behaviour among neotropical and paleotropical bats. *Journal of Mammalian Evolution* 2: 57–77; <http://doi.org/10.1007/BF01464350>
- Kunz, T.H., S.K. Robson & K.A. Nagy (1998). Economics of harem maintenance in the greater spear-nosed bat, *Phyllostomus hastatus*. *Journal of Mammalogy* 79: 23–30; <http://doi.org/10.2307/1382993>
- Lim, B.L. (1966). Abundance and distribution of Malaysian bats in different ecological habitats. *Federation Museums Journal* 11: 62–76.
- Marimuthu, G., K.E. Rajan, J. Koilraj, S.S. Isaac & J. Balasingh (1998). Observations on the foraging behaviour of a tent-roosting megachiropteran bat, *Cynopterus sphinx*. *Biotropica* 30: 321–324; <http://doi.org/10.1111/j.1744-7429.1998.tb00066.x>
- Marshall, A.G. (1983). Bats, flowers and fruit: evolutionary relationships in the Old World. *Biological Journal of the Linnean Society* 20: 115–135; <http://doi.org/10.1111/j.1095-8312.1983.tb01593.x>
- McComb, K. (1991). Female choice for high roaring rates in red deer, *Cervus elaphus*. *Animal Behaviour* 41: 79–88; [http://doi.org/10.1016/S0003-3472\(05\)80504-4](http://doi.org/10.1016/S0003-3472(05)80504-4)
- McCracken, G.F. & J.W. Bradbury (1977). Paternity and heterogeneity in the polygynous bat, *Phyllostomus hastatus*. *Science* 198: 303–306; <http://doi.org/10.1126/science.198.4314.303>
- Morrison, D.W. (1978). Lunar phobia in a Neotropical Fruit Bat, *Artibeus jamaicensis* (Chiroptera: Phyllostomidae). *Animal Behaviour* 26: 852–855; [http://doi.org/10.1016/0003-3472\(78\)90151-3](http://doi.org/10.1016/0003-3472(78)90151-3)
- Ngamprasertwong, T., S.B. Piernney, I. Mackie & P.A. Racey (2014). Roosting habits of Daubenton's Bat (*Myotis daubentonii*) during reproduction differs between adjacent river valleys. *Acta Chiropterologica* 16: 337–347; <http://doi.org/10.3161/150811014X687297>
- Ortega, J., J.E. Maldonado, G.S. Wilkinson, H.T. Arita & R.C. Fleischer (2003). Male dominance, paternity and relatedness in the Jamaican Fruit-eating Bat (*Artibeus jamaicensis*). *Molecular Ecology* 12: 2409–2415; <http://doi.org/10.1046/j.1365-294X.2003.01924.x>
- Phua, P.B. & R.T. Corlett (1989). Seed dispersal by the Lesser Short-nosed Fruit Bat (*Cynopterus brachyotis*, Pteropodidae, Megachiroptera). *Malayan Natural Journal* 42: 251–256.
- Simmons, N.B. (2015). Bats Magazine. Bat Conservation International. *Bats* 34: 1–23.
- Stephenraj, D., S.S. Isaac, T.H. Kunz & J.A. Stanley (2010). Foraging behaviour of Megachiropteran Bats (*Chiroptera: Pteropodidae*) in Courtallam, Tamilnadu, South India. *Bioinfolet* 7: 175–180.
- Tan, K.H., A. Zubaid & T.H. Kunz (1997). Tent construction and social organization in *Cynopterus brachyotis* (Muller) (Chiroptera: Pteropodidae) in Peninsular Malaysia. *Journal of Natural History* 31: 1605–1621; <http://doi.org/10.1080/00222939700770861>
- Tan, K.H., A. Zubaid & T.H. Kunz (1998). Food habits of *Cynopterus brachyotis* (Muller) (Chiroptera: Pteropodidae) in Peninsular Malaysia. *Journal of Tropical Ecology* 14: 299–307; <http://doi.org/10.1017/S0266467498000236>
- Wilkinson, G.S. (1985). The social organization of the common vampire bat. II. Mating system, genetic structure and relatedness. *Behavioural Ecology and Sociobiology* 17: 123–134; <http://doi.org/10.1007/BF00299243>
- Zubaid, A. (1994). Vertical stratification of Pteropodid bats in a Malaysian lowland rainforest. *Mammalia* 58: 309–311; <http://doi.org/10.1017/S0266467400008191>





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