



ROOST SELECTION AND ROOSTING ECOLOGY OF FULVOUS FRUIT BAT, *ROUSETTUS LESCHENAULTI* (PTEROPODIDAE)

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ABSTRACT

A total of nine colonies of fulvous fruit bat, *Rousettus leschenaulti* consist about 5400 individuals observed in this study between August 2009 and March 2014. The frugivorous bats, *R. leschenaulti* have a wide habitat tolerance but their day roosts were invariably humid. *Rousettus leschenaulti* preferred to roost in deserted buildings, historical monuments, walls of deep well and tunnels. The known roost sites of *R. leschenaulti* were stable and long lasting and undisturbed. The colony of *R. leschenaulti* was perpetually noisy. Roosting habits and the population size of *R. leschenaulti* influenced by various intrinsic and extrinsic factors. These bats roosted in hanging position from the ceiling of the building that offered a high degree of protection from predators. Thus, it is important to preserve the existing roosting habitats of *R. leschenaulti* as it plays vital roles in balancing the ecosystem, seed dispersal and regeneration of forests.

KEY WORDS: *Rousettus leschenaulti*, day roosts, Pteropodidae, morphometric.

INTRODUCTION

The order Chiroptera is the second largest group of mammals in the world. At present there are about 1,232 extant species comprising altogether globally and represents a quarter of the total 5,487 mammal species of the world (Schipper *et al.*, 2008; Simmons, 2010; Kunz *et al.*, 2011). India is relatively rich in bat fauna comprising approximately 119 species of bats out of which 14 species are fruit-eating or megachiropteran (Pteropodidae) belongs to 8 genus and the remaining are insect eating or microchiropteran bats (Bates & Harrison, 1997). The megachiropteran bats are the old world fruit bats relying on their visual acuity (Teeling *et al.*, 2000; Jones *et al.*, 2002) and olfactory system to navigate and forage (Safi & Dechmann, 2005). This group comprises of those bats that eat fruits, nectar, pollen, leaves *etc.* They have a face that resembles that a fox, to some extent, and also have good eye sight which helps in finding the food. All bats are economically important to our society. The fruit bats benefit us pollination and seed dispersal and play crucial role in the maintenance of forest ecosystems worldwide (Wiles & Fujita, 1992). Bats spend over half of their lives in roosts, which provide them protection and sites for resting, mating, rearing young and social interactions (Kunz, 1982). The understanding of the roosting ecology of bats is absolutely important for their conservation (Fenton & Rautenbach, 1998). Disturbance and destruction of day roost sites is a major factor for decline of bat population (Kunz, 1982). Many factors, such as microclimate, structural characteristics of the roost, surrounding habitat, disturbance by human and risk of

predation may influence roost selection by bats (Brigham & Fenton, 1986; Usman, 1988; Churchill, 1991; Vonhof & Barclay, 1996; Entwistle *et al.*, 1997; Williams & Brittingham, 1997; Jenkins *et al.*, 1998; Sedgely & O'Donnel, 1999). The fulvous fruit bat, *Rousettus leschenaulti* (Pteropodidae), is a medium-sized bat largely distributed in Indian subcontinents. It is very common species which has a wide habitat tolerance. It lives in colonies which may vary from hundreds to thousands individuals. Generally, *R. leschenaulti* roosts are located in caves, deserted buildings, temples and unused tunnels (Chandrashekar & Marimuthu, 1994). Occasionally, solitary males may be found in the dense foliage of a large-leaved tree or palm (Phillips, 1980). Usually the both sexes live together, although juveniles when free of maternal care live separate from adults. Individuals hangs by both feet from the sides or roofs of their roosts and spend much of the day wrangling, mating or squabbling amongst themselves, when not engaged in sleeping or grooming their fur (Bates & Harrison, 1997). They are often extremely noisy. Bats of this species feed on both wild and cultivated fruits including guava, lychee, banana, and papaya (Tang *et al.*, 2008).

MATERIALS & METHODS

The state Uttar Pradesh has a total area of 243,286 sq km and situated in the northern part of India sharing international borders with Nepal. It is surrounded by the Uttarakhand to the north, Delhi and Haryana to the northwest, Rajasthan to the west, Madhya Pradesh to the southwest, Bihar to the east and Jharkhand to the southeast. The major rivers of Uttar Pradesh are the Yamuna, Ganges, Ghaghara and Sarayu. The weather of the state has primarily subtropical features. The state

experiences four seasons and has a humid temperate climate. Summer is hot and dry, with average temperature of 45°C accompanied by dust laden winds. Monsoon receives around 85% of the average annual rainfall of 990 mm. Winter is cold with temperatures dropping down to 4°C. Uttar Pradesh has a number of historical monuments at Agra, Varanasi, Kushinagar, Chitrakoot, Lucknow, Jhansi, Allahabad and Mathura. Historical monuments, old temples and caves tend to be the ideal places for bat roosting. The roosting ecology of fulvous fruit bat, *Rousettus leschenaulti* was carried out between August 2009 and March 2014. The roost searches were carried out at historical monuments, abandoned buildings, caves, old temples and mosques, and reserve forests to find the roosts of bats. The tree cavity / crevices observed in the study area were also searched during the daytime to find the occupancy of the bats. During the field survey, information related the roost characteristics of building, tree and information about their threat were collected. The type of roosts such as historical monuments, unused building, fort, temple, old bridge, deep wells, caves, crevices, tree holes, and other type of roosts were thoroughly searched for the occurrence of bats and geographical location were recorded. The building characteristics such as type of building, height of the roost, roost area, number of groups, total number of occupants, temperature and humidity were measured. The colony size was assessed through direct count using binocular and photographic methods (Tuttle, 1979). Many other features, such as microclimate, structural characteristics of the roost, surrounding habitats, disturbance by humans and risk of predation were also recorded.

Bats were captured by standard mist netting methods (Kunz & Kurta, 1988), using 3 meter nylon mist nets (AVINET, USA) / Hoop net (Self designed) at different locations of Uttar Pradesh for the identification. All nets were erected between 1800 h and 0400 h at 2.6 m height on flight paths of bats. The mist net is the most effective

way to capture flying bats and is the best way to study bats, which are not found in roosts. Some of the advantages of using mist nets to capture bats are that they are lightweight, compact and easily transported and erected in the field. Black is the most common “colour” and likely the most suitable for capturing bats. When a bat flies into a net, it usually drops into a pocket formed by the netting and shelf cord. Captured bats were held individually in cloth bags. Morphological measurements such as head and body length (HB), tail length (T), hindfoot length (HF), length of tibia (TIB), forearm length (FA), wing span (WSP), wing area, thumb length, length of second metacarpal, length of third metacarpal, first phalanx of the third metacarpal, second phalanx of the third metacarpal, fourth metacarpal, first phalanx of the fourth metacarpal, second phalanx of fourth metacarpal, fifth metacarpal, first phalanx of the fifth metacarpal, second phalanx of fifth metacarpal, ear (E), sex, maxillary tooththrow, mandibular tooththrow and body mass were recorded from each captured bat individually by digital venire calipers and electronic balance.

RESULTS

The fulvous fruit bat, *Rousettus leschenaultia* (Desmarest, 1820) is a medium-sized bat, widely distributed in India (Figure 1). It lives in caves or man-made structures (i.e. abandoned houses or water tunnels) etc. It is a colonial species which lives together in large population containing hundreds or even thousands of individuals at the same roosting sites. The average head and body length was 123.66 ± 6.55 mm, the ear length and width were 18.10 ± 0.93 mm and 10.60 ± 0.70 mm, respectively. The forearm length was 78.99 ± 2.34 mm and the length of hind foot was 9.05 ± 1.70 mm (Table 1). The morphological measurements such as length of 3rd metacarpal, 1st phalanx on 3rd metacarpal, 2nd phalanx on 3rd metacarpal, length of 4th metacarpal, 1st phalanx on 4th metacarpal, 2nd phalanx on 4th metacarpal, length of 5th metacarpal, wing span, wing area, tibia length and thumb length were given in Table 1.



FIGURE 1: Indian fulvous fruit bat, *Rousettus leschenaulti* (male)

TABLE 1: Morphological measurements of *Rousettus leschenaulti*. Values are given as mean \pm SD.

Morphological parameters (mm)	Male (n=5)	Female (n=4)	Combined (&) Mean \pm SD
Head and body length	121.60 \pm 7.03	126.22 \pm 5.72	123.66 \pm 6.55
Head length	39.23 \pm 2.94	34.77 \pm 0.52	37.25 \pm 3.15
Tail length	11.62 \pm 1.99	10.85 \pm 1.78	11.28 \pm 1.83
Hindfoot length	9.69 \pm 1.11	8.25 \pm 2.13	9.05 \pm 1.70
Tibia length	33.29 \pm 4.39	36.59 \pm 4.48	34.76 \pm 4.49
Forearm length	78.90 \pm 3.13	79.08 \pm 1.24	78.99 \pm 2.34
Ear length	18.61 \pm 0.64	17.45 \pm 0.87	18.10 \pm 0.93
Ear width	10.47 \pm 0.71	10.76 \pm 0.75	10.60 \pm 0.70
Tragus	Ab	Ab	Ab
Wing span	369.59 \pm 57.93	445.50 \pm 34.66	403.33 \pm 61.06
Wing Area (cm ²)	319.40 \pm 12.99	329.50 \pm 23.52	323.89 \pm 17.89
Thumb length	25.55 \pm 0.74	26.08 \pm 1.13	25.79 \pm 0.91
Length of second metacarpal	39.93 \pm 8.39	39.86 \pm 8.89	39.90 \pm 8.05
Length of third metacarpal	48.67 \pm 3.26	55.97 \pm 3.47	51.92 \pm 4.96
First phalanx of the third metacarpal	31.66 \pm 2.56	24.11 \pm 12.22	28.31 \pm 8.67
Second phalanx of the third metacarpal	40.92 \pm 2.18	40.30 \pm 1.37	40.65 \pm 1.79
Fourth metacarpal	46.84 \pm 2.89	52.44 \pm 7.19	49.33 \pm 5.68
First phalanx of the fourth metacarpal	25.08 \pm 1.81	33.30 \pm 11.28	28.74 \pm 8.26
Second phalanx of fourth metacarpal	25.85 \pm 2.25	26.52 \pm 2.32	26.15 \pm 2.16
Fifth metacarpal	45.93 \pm 4.77	50.12 \pm 6.40	47.80 \pm 5.63
First phalanx of the fifth metacarpal	23.46 \pm 2.01	24.38 \pm 3.00	23.88 \pm 2.37
Second phalanx of fifth metacarpal	20.79 \pm 6.19	22.08 \pm 7.12	21.37 \pm 6.22
Body weight (g)	67.20 \pm 15.42	86.50 \pm 11.56	75.78 \pm 16.51
Maxillary toothrow	14.17 \pm 0.61	14.76 \pm 0.55	14.44 \pm 0.63
Mandibular toothrow	14.44 \pm 0.63	15.33 \pm 0.39	14.84 \pm 0.69

A total of nine colonies of *R. leschenaulti* consist about 5400 individuals were observed in the study area (Table 2). All nine colonies were located in the historical monuments which had less human interference. The population size of colonies ranged from 54 – 2000. The temperature and humidity of the roosting sites were almost

stable without much variation. The average temperature and humidity of *R. leschenaulti* colonies were 31.22 ± 3.15 °C and 69.44 ± 3.32 %, respectively. The average height of the roosts was 5.73 ± 2.05 m from the ground. The colony located in a monument at Banda shared the roost with *Taphozous nudiventris*.

TABLE 2. Roost location and roost characteristics of *Rousettus leschenaulti*.

S. No.	Roost location	Type of building	Roost characteristics					
			Roost height (m)	Floor area (Sqf)	No. of groups / harem	Number of occupants	Temperature (°C)	Humidity (%)
1	Fort of Bhuragarh, Banda (25°28'33.34" N 80°18'33.63" E)	Historical monument	6	600	1	1000 - 1200	33	72
2	Dashrath Mahal, Ayodhya, Faizabad (26°47'45.49" N 82°11'47.38" E)	Historical monument	6	420	4	2000	30	65
3	Raj Sadan, Ayodhya, Faizabad (26°47'31.88" N 80°12'19.98" E)	Historical monument	4.5	180	3	291	30	65
4	Bahu Begam Maqbara, Faizabad, (26°45'58.02" N 82°08'40.30" E)	Historical monument	9	150	2	105	33	72
5	Badi Masjid (Mosque), Jaunpur (25°45'32.61" N 82°41'06.04" E)	Historical monument	4.5	180	3	500	35	68

6	Jhansi fort, Jhansi (25°27'28.24" N 78°34'32.42" E)	Historical monument	5.4	600	2	120	35	75
7	Shahi bauli, Bara imambara, Lucknow (26°52'07.98" N 80°54'49.27" E)	Historical monument	3.6	120	1	54	30	68
8	Chunar fort, Mirzapur (25°07'15.02" N 82°52'34.77" E)	Tunnel of Well	9	100	1	700 - 800	30	70
9	King's Palace, Raebareli (26°14'00.00" N 81°13'59.88" E)	Abandoned building	3.6	180	3	400	25	70

A large colony consists about 1000 individuals of *R. leschenaulti* found in the Fort of Bhuragarh, Banda (25°28'33.34" N 80°18'33.63" E). The height of the roost was about 6 m from the ground level. The total floor area of the colony was around 600 square feet. The relative temperature and humidity of the colony were 33 °C and 72 %, respectively. The colony was gregarious and extremely noisy.

A colony consists about 1700 individuals of *R. leschenaulti* observed in an unused building at Dashrath Mahal, Ayodhya (26°47'45.49" N 82°11'47.38" E). The

bats were roosted on wooden roof at about 6 m height from the ground (Figure 2). It was a century old temple situated near the Hanuman Gharhi, Ajudhya, Faizabad. There was an orchard of *Psidium guajava* and *Carica papaya* adjacent to the roost site. Further, the roosting site was located nearer to the river Yamuna. As per the local residents the colony exists for last two decades. The colony located at Raj Sadan, Ayodhya (26°47'31.88" N 80°12'19.98" E) had about 291 individuals of *R. leschenaulti*. It was also located a part of historical monument. The relative temperature and humidity of the roost site were 30 °C and 65 %, respectively.



FIGURE 2: A colony of *Rousettus leschenaulti* at King Dashrath Mahal (Palace), Ayodhya, Faizabad.

Akin to other colonies at Faizabad, a colony of *R. leschenaulti* consists of 105 individuals observed at Bahu Begam Maqbara (Mosque), Faizabad (26°45'58.02"

N 82°08'40.30" E). Bahu Begum Maqbara is the Tomb of Queen Bride Begum Unmatuzzohra Bano alias Bahu Begum a memorial built for queen of Nawab Shuja-ud-Daula. It was one

of the tallest buildings in Faizabad. The bats were hanging at a corner of a room. The height of the roost was 9 m from the ground level. The roost site was surrounded by a large number of fruit plants such as *P. guajava*, *C. papaya*, *M. acuminata*, *Z. mauritiana*, *A. indica*, *F. religiosa*, *F. glomerata*, and *F. bengalensis*. These trees are suitable resource for night roosts as well as feeding roosts to *R. leschenaulti*. At Jaunpur, a colony of *R. leschenaulti* consists about 500 individuals observed in a dome of Badi Masjid (Mosque) (25°45'32.61" N 82°41'06.04" E). The mosque was constructed by late Firoj Shah Tuglak during 13th century. The temperature and relative humidity of the mosque ranged from 30–33 °C and 65–70 %, respectively. *Roussettus leschenaulti* gathered as big cluster varied from 150 – 300 individuals. The height of the roost was about 4.5 m from the ground. The colony was surrounded by large trees such as *M. indica*, *E jambolana*, *F. religiosa* and *F. glomerata*.

An age-old colony of *R. leschenaulti* consists of 120 individuals observed at Jhansi fort, Jhansi (25°27'28.24" N 78°34'32.42" E). The height of the roost was 5.4 m from the ground. The relative temperature and humidity were 35 °C and 75 %, respectively. The bats were occupied the wooden ceiling of a room. There were two colonies of *R. leschenaulti* observed on the wall of deep wells located in old monuments. Among the two colonies, a small colony consists of 50 – 60 individual observed on the wall of a deep well at Shahi Baoli, Bara imambara, Lucknow. Asaf-ud-Daulah built one of the most unique buildings that Shahi Baoli. It was constructed around a large well that had been initially dug as a reservoir for storing water for construction work near the Imambara. It turned out to be a perennial source of water, being connected underground with the river flowing nearby (26°52'07.98" N 80°54'49.27" E). The particular height of the roost was 3.6 m from the ground level. Another large colony consists 700 individuals of *R. leschenaulti* observed in the tunnel of a deep well at Chunar fort, Mirzapur. The roost was located at about 9 m depth of the well. At Raebareli, a colony consists of 300 individuals observed at King Palace, Khajurganj Valley (26°14'00.00" N 81°13'59.88" E). The bats were hanging on the ceiling of a room in the monument. The height of the roost was 3.6 m from the ground. There was an orchard closest to the roost. The temperature and relative humidity of the roost were 22 °C and 60 – 70 %, respectively.

DISCUSSION & CONCLUSION

The current study reveals that *Roussettus leschenaulti* found roost in abandoned building and historical monuments. It reveals the less availability of suitable plant roosts and more availability buildings roost in the study area. The numbers of occupants in building roosts are very high compared to the plant roosts. They prefer the unused building because the building roosts are stable, long lasting and safe during natural calamities. This suggests that the species can tolerate humans in the vicinity of their roost. According to Krishna & Dominic (1985) in Uttar

Pradesh the sexes live separately, except during the breeding season (October – March) and in the winter months. The morphometric data obtained during the present study was compared with earlier studies on this species from India. The mean values for head and body length, ear length, forearm length, and hind foot length of all *Roussettus leschenaulti* were within the ranges given by Bates & Harrison (1997).

The fulvous fruit bat (*Roussettus leschenaulti*) was widely distributed in the study area and occupied large and old monuments. The monuments located in Uttar Pradesh have harboured a large population of *R. leschenaulti*. The bats might have preferred the monuments as roosting sites due to their stable temperature and relative humidity throughout year. *Roussettus leschenaulti* known to share its roost with other bats and in the present study it shared the roost with *Taphozous nudiventris*. Like other frugivorous bats, *R. leschenaulti* disperses seeds of many fruiting trees such as *M. indica*, *E jambolana*, *F. religiosa* and *F. glomerata*. Bates & Harrison (1997) reported that the fulvous fruit bat, *R. leschenaulti* has a widespread distribution in India and lives in colonies which may vary from hundreds to several thousands. The roost sites of *R. leschenaulti* are included caves, deserted buildings and disused tunnels, wells and temples (Phillips, 1980; Chandrashekar & Marimuthu, 1994; Vanitharani, 1997). This is the only frugivorous bat species in India that is able to navigate in complete darkness by echolocation, as a result it could occupy the roosting sites where complete darkness prevails (Sreenivasan & Bhat, 1974). The results of present study are consistent with the earlier reports on *R. leschenaulti*. The frugivorous bats, *R. leschenaulti* have a wide habitat tolerance but their day roosts are invariably humid and dark places like the deserted buildings, historical monuments and tunnels etc. The known roost sites of *R. leschenaulti* are stable, undisturbed, and long lasting. The colony of *R. leschenaulti* was perpetually noisy. Roosting habits, the preference for light while roosting and the population size of each bat species are differentially influenced by various intrinsic and extrinsic parameters. These bats roosted in hanging position from the ceiling of the building that offered a high degree of protection from predators. The degree of cluster fidelity was sex dependent. The females remained in a given cluster throughout the day but the males shifted from one cluster to another. This behavior resulted in high pitched vociferous squabbling that made these groups the noisiest amongst all.

Fruit bats play a pivotal role as pollinators and seed dispersers for a diverse array of plants (Fleming & Estrada, 1996; Banack, 1998; Shilton, *et al.*, 1999; Godinez-Alvarez *et al.*, 2002). Around 300 plant species of nearly 200 genera mainly rely on large populations of Old World fruit bats for their propagation (Marshall, 1983; Fujita & Tuttle, 1991). Thus, it is critically important to preserve the existing roosting habitats of bats in Uttar Pradesh, because bats play vital role in balancing the ecosystem, seed dispersal, regeneration of forests.

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