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Ecological aspects of roosting habits of frugivorous bat, *Rousettus leschenaulti* in Ṭawi Wildlife Sanctuary, Mizoram

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Abstract

The roosting site of the frugivorous bat, *Rousettus leschenaulti* of the Ṭawi Wildlife Sanctuary was surveyed and the population was determined. The abiotic parameters such as temperature, relative humidity, light intensity, roosting area, the structural details of roosting site, etc. as well as the biotic parameters such as the composition of age and sex, roosting pattern, seasonal variation in the roosting behaviour, etc. were determined. The roosting site, RS was occupied by a colony of over 1215 individuals. The variation in light intensity (0.2–0.8 lux), temperature (28 ± 0.2°C) and relative humidity (94 ± 1%) was least in this roosting site because of the closed and insulated nature of the roost. This is a specious and dark roosting site. These bats roosted in four types of clusters namely mixed-sex adults, mixed-sex sub-adults, pregnant females with lactating mothers, and the mixed-sex old individuals. The formation of clusters was based on the sex, age and reproductive status of individuals. The sex-bias favoured females.

Key words: Frugivorous; *Rousettus leschenaulti*; roost; Ṭawi Wildlife Sanctuary.

Introduction

Roost is a place where bats settle or congregate to rest in the day or night. Roosts protect the bats from predators and inclement weather. They provide a suitable place for mating, rearing young ones, social interaction and hibernation.[1,2] Bat roosts may be located at a considerable distance from the foraging area.[3] Social bats usually roost in caves, buildings, tree hollows, animal burrows, abandoned mines, temple ruins, etc., while solitary bats roost amongst tree leaves, in the rock crevices and other suitable habitats. Some bats also roost in the holes and hollows of the trees created naturally or by the activities of animals like beetles, birds, etc.[4] In tropical forests, bats modify the leaves of certain plants for the roost. A few insectivorous bat species roost amidst dense foliage.[5] The world's largest aggregations of bats are found in caves of temperate and tropical regions.

Bats spend half of their life-time in the roosts therefore the selection of the roosting site is cru-

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cial. It is influenced by the microclimate, surrounding vegetation, human interference, structural characteristic of the roost, risk of predation and the availability of food throughout the year.[6-8] However, a few roosting sites are avoided by the bats due to extreme humidity and temperature. The abundance of bat populations could depend on the availability of suitable roosting sites.[9] Moreover, the distribution of cave-dwelling bats depends on the physical dimensions, microclimatic conditions and topography of the caves.[10,11]

Males and females of several bat species aggregate only during the breeding season and thereafter roost separately.[12] In *Megaderma lyra* (E. Geoffroy, 1810), the pregnant females and mothers with infants roosted separately.[13] The young bats of *Rousettus leschenaulti* (Desmarest, 1820) roosted in separate groups away from the adults.[14] A few tropical bat species like the *Rousettus* species, *Taphozous melanopogon* (Temminck, 1841), *Rhinopoma hardwickei* (Gray, 1831) and *Rhinolophus lepidus* (Blyth, 1844) exhibited sexual segregation when the young ones were reared by mothers but they showed a mixed association at other times.[15] Aggression and combating among roosting bats are common during the day due to intense competition for an appropriate roosting place or mating partner.[16,17]

The aim of the present study was to survey roosting site of *R. leschenaulti* in the Tawi Wildlife Sanctuary with respect to both abiotic and biotic parameters. The ambient temperature, relative humidity, light intensity, the age and sex composition were determined, and their influence on the population size was investigated.

Materials and Methods

Roosting habits of bat, *R. leschenaulti* of the Tawi Wildlife Sanctuary (23°N30' and 93° E) was studied from March 2012 to March 2013. The entire area of the Sanctuary was surveyed to locate the roosting site of these bats and ecological parameters of the roosting site were studied. Tawi Wildlife has a pleasant and equable warm climate throughout the year with moderate to chilly winter during November-January at higher altitudes. The temperature and relative humidity in the sanctuary were monitored adjacent to the roosting site of the bats, *R. leschenaulti*.

The proper roosting area (m^2) where the bats actually preferred to roost was measured as roosting site. Ambient temperature and relative humidity were monitored continuously (Lambrecht-Goettingen thermo-hygrograph drums, Germany), while the light intensity (Lux -meter, UDT, 40-X Optometer, USA) and the noise level (M-407727, Extech Instruments, USA) at roosting site were measured on a fixed day in the first week of every month at 0600, 0900, 1200, 1500 and 1800 h. Light intensity was determined by holding the sensor of the lux meter towards the brightest light spot at roosting site. Roosting pattern was recorded in the darkness by using the night vision mode of a video camera (Sony Digital Video Camera, DCR-TRN-320E, Japan). Its infra-red light source did not disturb the bats, however, the images on the LCD screen of the camera or on the TV screen were in black and white. Initially, the video recordings on the memory card were transferred to CDs and then viewed on the TV screen with the help of a VCD player. The roosting pattern, age and the sex-composition of each cluster, the position of bats while roosting, and their number in a given cluster were determined by viewing the video recordings in a slow-motion display or freeze-mode on a 74 cm screen of a TV for detail analysis. These parameters were also verified by using battery-powered torch lights that had a combination of filters transmitting the red light >610 nm. The light stayed on from a few seconds to a few minutes during which the bats were found to be undisturbed. White light was not used for observing the roosting behaviour of the bats since it disturbed them.

The total number and composition of sex and age were determined by trapping all bats at roost in the first week of July. Every captured animal was visually inspected and placed into three age-groups: adults, sub-adults and juveniles. The reproductive status of each animal was determined as follows. Males were classified as non-reproductive if they had abdominal testis, and reproductive if they had scrotal testis. Females were classified as non-reproductive if they had normal abdomen and non-apparent nipples; pregnancy was detected by abdominal inspection; lactating females if they had enlarged nipples (milk secretion was verified by light pressure on the nipples) and post-lactating females if they had hair surrounding nipples (milk was not produced after light pressure on nipples). Bats emerging at dusk were trapped by using mist-nets (Avinet-Dryden NY 13053-1103, USA). Few bats that managed to escape from the nets to the foraging grounds were captured in the field by using mist-nets tied to bamboo poles.[18] Males were banded by securing a split-ring with embossed numbers, on the right forearm and females on the left forearm.[19] Thereafter they were recaptured twice, in the third and fourth week of August in order to ascertain whether or not each bat was tagged. Non-volant pups were marked on both ears with marker pens of four different colours. Bats were released immediately after identification. In ten adult males, the length of the forearm was measured using a steel scale to the nearest 0.1 mm and the body weight was determined to the nearest 0.1 g using a spring balance (Avinet, USA). Dead bats found on the floor of the roosting site were preserved in 75% ethanol for species identification.

RESULTS

The roosting site is designated as RS and the location in the Tawi Wildlife Sanctuary is shown in Fig. 1. The monthly average temperature and relative humidity (max. and min.) of the Tawi Wildlife Sanctuary were in the range of 12-36°C and 65-96%, respectively (Fig. 2). The roosting site was characterized by typical biotic and abiotic parameters that influenced the bat population of the roost. The ecological as-

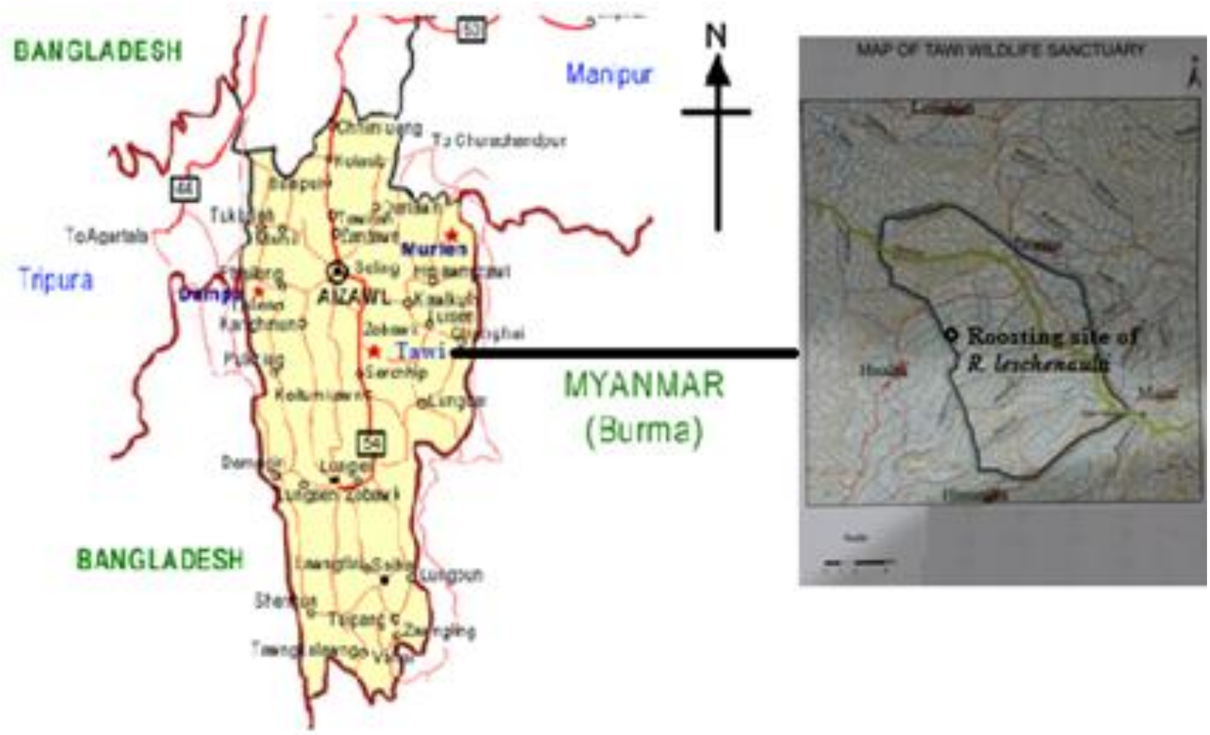

Figure 1. The map showing the locations of roosting site (RS) of R. leschenaulti in Tawi Wildlife Sanctuary.

Table 1. Ecological parameters of the roosting site (RS) of *R. leschenaulti* was determined from March 2012 to March 2013. The range of light intensity in lux (LI), the temperature in °C (Temp.), % relative humidity (R.H.) and noise level in decibels (dB) are given for this roosting site.

Roosting site (RS)	Location and Roosting area (m^2)	Bat Species	No. of bats	LI, Temp., R.H., dB.
RS	The ceiling (143.9 m^2) of the cave	*Rousettus leschenaulti*	12,15	0.2-0.8 lux, 30-31°C, 93-95% R.H., 21-265 dB.

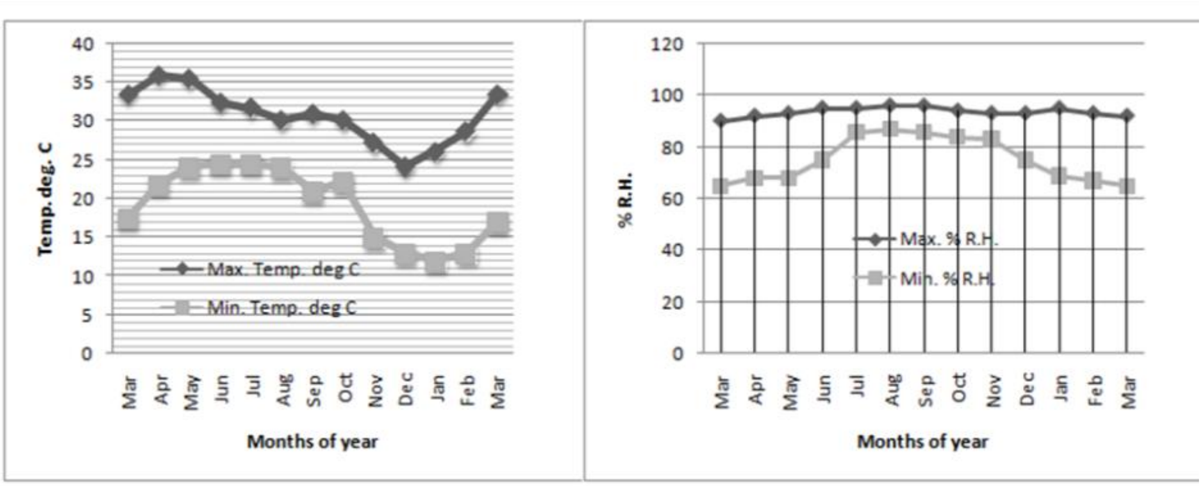

Figure 2. Average monthly maximum and minimum ambient temperature (Temp. °C) and relative humidity (% R.H.) in the Tawi Wildlife Sanctuary determined from March 2012 to March 2013. Each symbol represents the mean ± SD, *N* = 28 in each graph. The seasonal variation in both parameters is evident.

pects of roosting site are summarized in Table 1.

Roosting site, RS

This roosting site was in the cave that was situated on the southeast side of the sanctuary adjacent to the orchards garden near the Hualtu Village. The main entrance is 5x8 feet wide. Complete darkness prevailed in the interior of the cave and one needed a flash-light to find the way in it. This was spacious and dark roosting site. The proper roosting area was 143.9 m^2. The monthly average maximum and minimum temperatures and relative humidity at this roosting site are shown in Figure 3. The temperature (28 ± 0.2°C) and relative humidity (94 ± 1%) were remarkably constant over the year. The light intensity varied from 0.2 lux to 0.8 lux. There was least variation in the temperature and relative humidity at this roosting site.

The largest breeding colony of 1215 fruit-eating bats of *Rousettus leschenaulti* (Desmarest, 1820) occupied this roost. The adults, sub-adults and juveniles roosted in clusters and the formation of clusters was dependent on the age, sex and reproductive status of the bats. Four types of clusters were observed as follows: mixed-sex adults, mixed-sex sub-adults, pregnant females with lactating mothers, and the mixed-sex old individuals. The roosting pattern of bats of each cluster differed in several ways as follows.

Clusters of mixed-sex adults

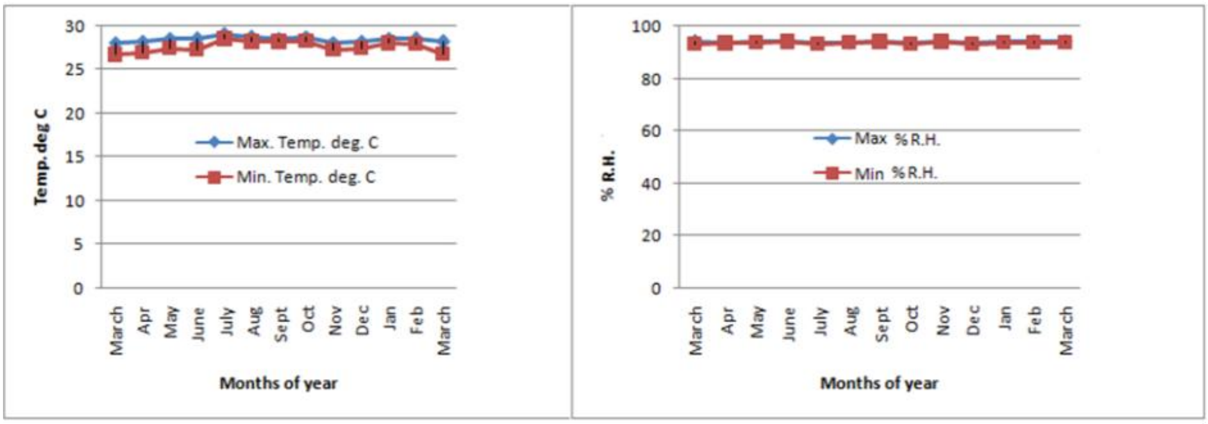

Figure 3. Average monthly maximum and minimum ambient temperature (Temp. °C) and relative humidity (% R.H.) from March 2012 to March 2013 at roosting site (RS). Each symbol represents the mean $\pm$ SD, *N* = 28 in each graph.

Adults of both sexes formed 11-16 clusters and each cluster comprised of 18-35 individuals. They roosted in the central part of the ceiling which was inaccessible to humans. Minimum spacing between two adjacent clusters was ~60 cm. Females showed a higher degree of cluster fidelity than the males, i.e., the females usually roosted in the same cluster throughout the day. The males, however, shifted from one cluster to another, apparently to seek a potential mating partner that resulted in frenzied squabbling and high pitched vocalization. Bats of these clusters were the nosiest amongst all. Mating was frequently observed in the noon. These bats contributed greatly to the dusk and dawn vocalization.

Clusters of mixed-sex sub-adults

Sub-adults of both sexes along with juveniles that were just weaned formed 9-18 clusters on the wall. Each cluster comprised of 5-12 animals. The degree of body contact was the highest amongst them as compared to that of other types of clusters. The minimum spacing between two adjacent clusters was ~20 cm. They exhibited a great degree of cluster fidelity. These groups also contributed to the high pitched vocalization prior to the dusk emergence and after the dawn return.

Clusters of pregnant females and lactating mothers

Pregnant females and lactating mothers with pups formed 10-14 clusters and they roosted in the ceiling ~3 m away from the clusters of mixed-sex adults. Each cluster comprised of 11-21 females. Loose huddling was observed amongst the pregnant females but not lactating mothers. Adult males never approached these females with the obvious intention of seeking a mating partner. These females also contributed to the loud audible vocalization prior to the dusk emergence and after the dawn return.

Clusters of old bats

The old bats of both sexes formed 11-14 clusters in three secluded corners of the ceiling. Each cluster comprised of 16-23 animals that huddled closely and never exhibited the behavioural components like power struggle, personal space, mating, etc. They neither participated in the light-sampling behaviour nor emerged with the young conspecifics at dusk. They were the quietest individuals amongst all.

This colony was perpetually noisy and the noise level was in the range of 21-265 dB. When

Table 2. Sex-composition, age distribution and total number of individuals of *Rousettus leschenaulti*.

Bat Species	No. of adult		No. of sub-adult		No. of juvenile		Total
	Male	Female	Male	Female	Male	Female	
R. leschenaulti	144	159	465	244	105	98	1215

torch light was flashed, hundreds of them swept out of the roost and made circling flights in the outer passage for several minutes before settling in a corner. When bright light was focused on the bats roosting in the darkness, their eyes glowed sharply against the dark background. The floor of this roosting site was completely covered by a thick layer (depth ~1.2 m) of guano apparently accumulated over the decades. Discarded plant-parts like fruits, seeds, leaves, etc. formed the top layer of the guano. Several invertebrates like spiders, cockroaches, beetles, scorpions, etc., and a few vertebrates like rats, snakes, lizards, etc. were detected in the guano. These animals were the components of the food-web of this roost. Males outnumbered females in this colony (Table 2).

Discussion

The least variation of temperature and high humidity prevails in the sanctuary are due to the presence of the virgin dense semi-evergreen forest. The ecosystems in the sanctuary are partly screened from exposure to direct sunlight at different times of the day throughout the year. Moreover, the sanctuary serves as a percolation gorge for the freshwater from the thick forest so that several perennial freshwater springs originate directly from the ground. This resulted in a spectacular diversity of the flora and fauna of the sanctuary ecosystems. It is applicable to the bat fauna of the sanctuary too. Twelve bat species having diverse ecology are found in the sanctuary. 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.

The frugivorous bats, *R. leschenaulti* have a wide habitat tolerance but their day roosts are invariably humid and dark places like the natural caves, deserted buildings, temple ruins, tunnels, etc. The number of bats in a roost could vary from 3 to over 10,000.[20] 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.[21] In the present study, a breeding colony of *R. leschenaulti* occupied such a roosting site (RS) characterized by remarkable constancy of the temperature, humidity and light intensity that in turn was attributed to the confined structure of this roost. These bats roosted in four types of clusters which were formed on the basis of sex, age and the reproductive status of individuals. Bats of each cluster had a characteristic roosting behavioural pattern.

Adults of both sexes formed the largest clusters which were widely spaced. These bats roosted in a hanging position from the ceiling of the cave that offered a high degree of protection from predators. It was obvious for them to stake a claim on such a roosting area since they were physically the strongest, and the only reproductive members of the colony. 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, apparently seeking a willing mate. This behaviour resulted in high pitched vociferous squabbling that made these groups the nosiest amongst all. The pregnant females and lactating mothers with infants formed loose clusters that were located in the ceiling, adjacent to the clusters of the mixed-sexed adults. The pregnant females huddled together but the lactating mothers were spaced from each other as if they needed more space to nurse and groom their pups. Adult males never approached these females to seek a sexual favour. Sub-adults of both sexes roosted together and formed tight clusters on the walls. The degree of body contact was the highest among them so as to conserve the energy by reducing the heat loss.[22] They exhibited a great degree of cluster fidelity. It is interesting to note that how the process of aging noticeably altered the roosting behaviour in these bats. The roosting pattern of the old bats of both sexes was entirely different from that of the other age-groups. They formed clusters in three secluded corners of the roosting site away from the younger conspecifics. They huddled closely and never participated in the light-sampling behaviour nor ever emerged with the young conspecifics at dusk.

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