

A Report on Bat Species Identified in Bareilly, Uttar Pradesh, India with a Brief Description of Their Ecology

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ABSTRACT

In a survey of the Indian Veterinary Research Institute campus and adjoining villages around Bareilly city of Uttar Pradesh, India, five species of bats (order Chiroptera) were identified and their morphometric features and habitat were examined. During the period from August, 2016 to July, 2018, a total of 24 individual bats were observed. They belonged to families Pteropodidae (*Pteropus giganteus*, *Rousettus leschenaultii*, *Cynopterus sphinx*) and Vespertilionidae (*Pipistrellus coromandra*, *Scotophilus heathii*). Based on morphometric measurements, PCR amplification and sequencing of mt DNA, COI gene and field surveys, the different species were recognised. In the study area, species of Fig trees, Sirius, Eucalyptus, Leechi, Mahua trees and other flora provide a suitable habitat for different frugivorous bat species. A brief note on the ecology of these bats is provided.

Key Words: Bat; Pteropodidae; Vespertilionidae; Ecology; Morphometry; Chiroptera

INTRODUCTION

Bats are the only flying placental mammals that are present all around the world except in Arctic, Antarctica and a few oceanic islands. They are the second largest order of mammals that evolved in Eocene period (50 million years ago) and diverged into 925 known species which constitute 20% of >4800 mammalian species (Wilson and Reeder 2005). Some experts believe that more than 1200 species, comprising a quarter of all the mammalian species, exist in different parts of the world (Schipper et al. 2008, Simmons 2010 and Kunz et al. 2011). Most of bats live in colony. Almost three fourths of bats are insectivorous and remaining feed on fruits, flower nectar and blood. In South Asia, there are 128 species of bats belonging to 8 families (Sreenivasalu et al. 2010) and in India 124 species (more than 90%) were identified (Saikia et al. 2017). Among this, 65% bats were seen in North east region of India (Ruedi et al. 2014). But the studies were restricted to certain localities

and new species were reported from different states every year (Dookia and Mishra 2018). *Hipposideros ater Nallamalensis*, a new bat species was identified in Andhra Pradesh in 2006 and Asiatic lesser yellow house bat or *Scotophilus kuhli* was found in Delhi for the first time in 2018. Moreover two new species, *Pipistrellus ceylonicus* and *Tylonycteris fulvida* were discovered in Assam recently. Although bats play a pivotal role in all types of ecosystems as pest controller and as pollinators in tropical rainforest, their potential role as reservoir for dangerous pathogens has drawn the attention of public health workers worldwide. As per Wildlife Protection Act, except Salim Ali's fruit bat and Wroughton's free-tailed bat, all other bats in India are considered as vermin.

External morphology and geometric morphometry were commonly used to identify the bat species, its flight and foraging habitat. However identifying the species with morphometry alone is difficult, now-a-days species identification in bat uses PCR-based mitochondrial DNA

16srRNA on faecal samples as in other wild species. PCR based species identification studies relies mainly on amplification two mtDNA genes (cyt b and COI) (Pastor-Beviá et al. 2014) and their sequencing.

The Indian Veterinary Research Institute Campus and adjoining villages in Bareilly provides suitable habitat for different bat species and prevailing species of bats were examined during the study period. The status and diversity of bat species prevalent in the area was studied by morphometry and DNA barcoding. The roosting sites were observed for understanding their habitat preference and foraging behavior.

STUDY AREA

The present study was undertaken in the campus of the Indian Veterinary Research Institute (IVRI), Izatnagar and in the adjoining villages in Bareilly which falls between 28° 20' to 28° 54' N and 78° 58' to 79° 47' E in western Uttar Pradesh (Figure 1A & 1B). Bareilly has a total area of 235 km² and a population density of about 3800 km⁻² (Census 2011). The climate has subtropical features with an average temperature of 45 °C in summer and 4 °C in winter, and average rainfall of 990 mm in monsoon. The city is on Ganges plain, leveled and well irrigated land for growing sugarcane, rice, pulses and wheat. The climatic conditions of the Institute campus significantly varied during the year. During the study

period, humidity was maximum in August (89.15%) and minimum in March (48.96%), whereas the highest temperature was recorded in May (44.17 °C) and lowest in January (4.71 °C) (Weather station, Physiology & Climatology division, IVRI).

METHODOLOGY:

During the period August, 2016 to July, 2018, fresh bat fecal samples were collected from their roosting and foraging areas in and around IVRI campus and adjoining villages in Bareilly. Clean polythene sheets measuring 2.0 X 2.0 m were placed under known bat roosting and foraging sites after sunset, 7.00 PM. The fresh fecal samples were collected the following morning between 5:30 to 6:00 AM in vials containing RNA later. The samples were then transported to the laboratory, labeled properly and stored at -80°C until analyzed. Detailed information of bat roosting and foraging areas (latitude, longitude, temperature, humidity of these areas, roosting and foraging tree species, activity of different bat species on climate basis and foraging vegetation and density) were noted. The colony size was assessed through direct count using binocular and photographic methods (Tuttle 1979). Bats, found dead or moribund were collected from different sites in the study area which included Bareilly city and nearby villages. They were either found clinging to the high voltage electrical wires, fish nets

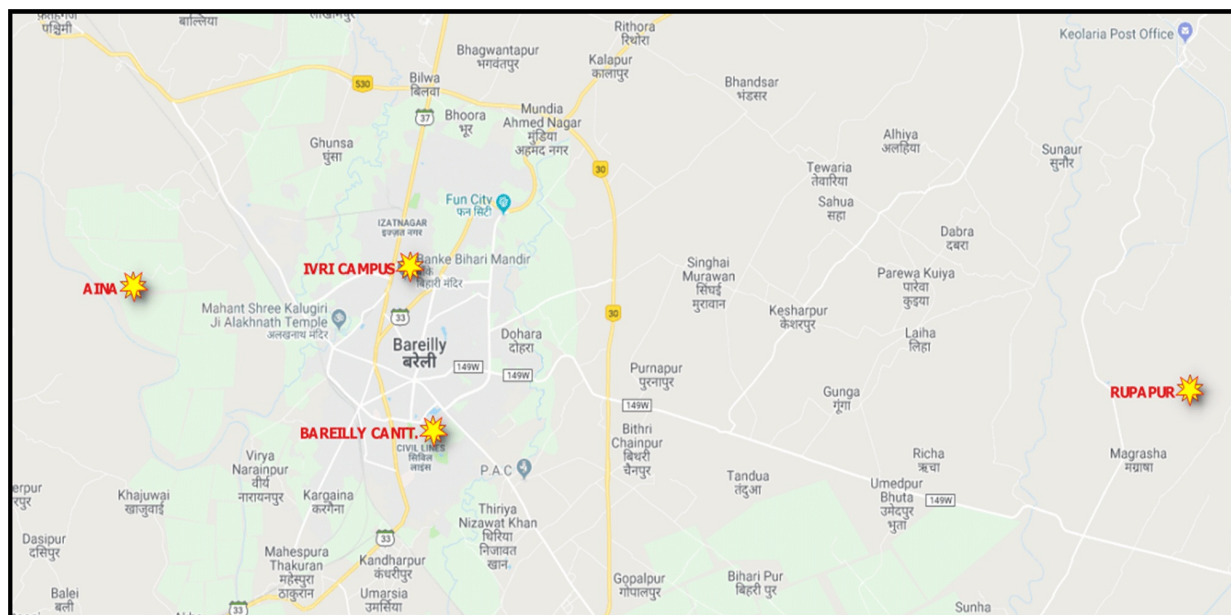


Figure 1A: Sighting location of bats in study area

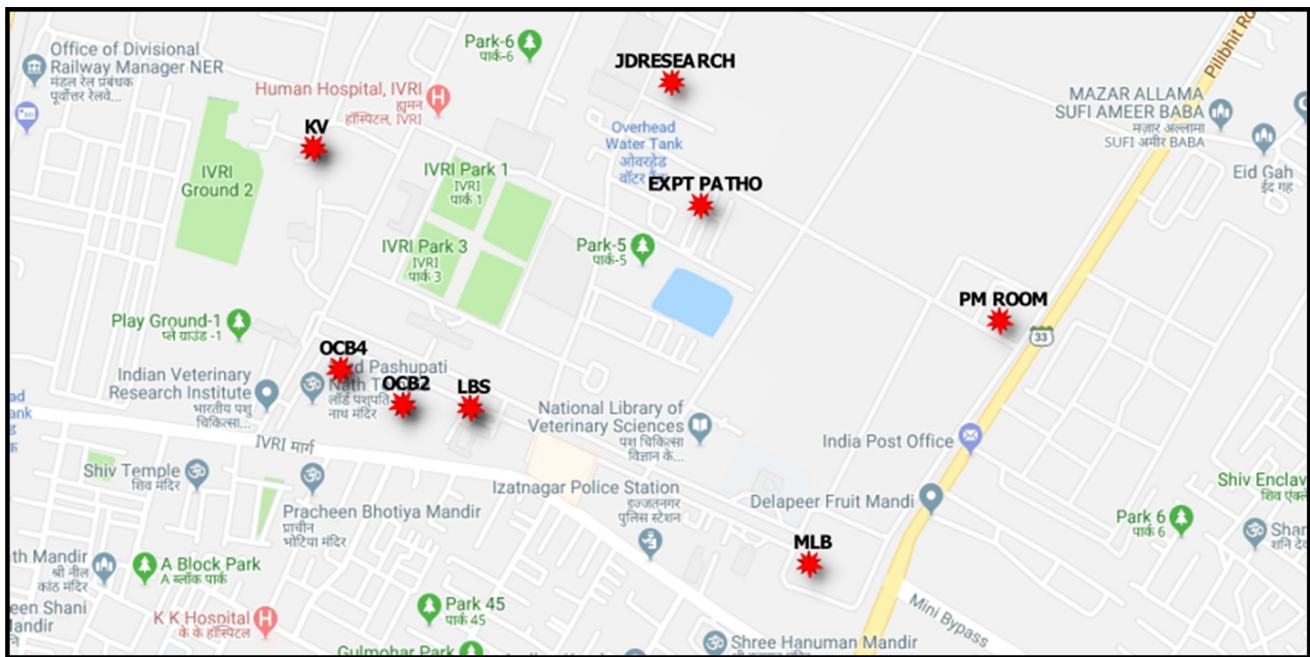


Figure 1B: Roosting and foraging areas of different bat species found in IVRI campus

over ponds or injured ones lying on the ground after a storm. The live *Pipistrelle* bats were captured using mist nets, permission for which was obtained from concerned agency.

Identification of bat species was carried out by PCR amplification of COI genes and by analyzing the morphometric measurements as well as some external key characters. The morphological measurements were recorded by digital vernier calipers and the data were compared with Bates and Harrison (1997) and recent available literatures. Details of the specimens collected during the study are provided in Table 1. The order wide species of Chiroptera were identified from the faecal samples by amplifying the mitochondrial gene Cytochrome-c oxidase-I (published primers) (Walker et al. 2016).

DNA Extraction, PCR Amplification and Sequencing:

The faecal samples collected from same locations were pooled together and resuspended in 1XPBS and homogenized in Fast prep-24 containing ceramic beads at a rate of 5.5M/S for 30 second. It was repeated 3-4 times based on the homogenization of the suspension. The collected homogenate was then centrifuged at 5000 RPM for 10 minutes and the supernatant was re-centrifuged at 13000 RPM for 20 minutes. A volume of 5 mL was

Table 1. Details of bat specimens used for morpho-metry during study periods

ID	Species	Sex	Age	Condition
BS1	Pteropus sp.	Female	Adult	Electrocuted
BS2	Cynopterus sp.	Female	Adult	Electrocuted
BS3	Pteropus sp.	Female	Adult	Electrocuted
BS4	Scotophilus sp.	Female	Adult	Dead
BS5	Pteropus sp.	Female	Adult	Moribund
BS6	Pteropus sp.	Female	Adult	Dead
BS7	Pteropus sp.	Male	Adult	Dead
BS8	Rousettus sp.	Female	Adult	Dead
BS9	Pteropus sp.	Male	Adult	Moribund
BS10	Pteropus sp.	Male	Adult	Injured
BS11	Pteropus sp.	Female	Adult	Dead
BS12	Pteropus sp.	Female	Adult	Electrocuted
BS13	Pteropus sp.	Male	Adult	Electrocuted
BS14	Pteropus sp.	Female	Adult	Injured
BS15	Pteropus sp.	Female	Adult	Electrocuted
BS16	Cynopterus sp.	Female	Adult	Moribund
BS17	Scotophilus sp.	Female	Adult	Injured
BS18	Pteropus sp.	Female	Adult	Electrocuted
BS19	Pipistrella sp.	Female	Adult	Live
BS20	Pipistrella sp.	Female	Adult	Live
BS21	Pipistrella sp.	Female	Adult	Live
BS22	Pipistrella sp.	Female	Adult	Live
BS23	Pipistrella sp.	Female	Adult	Live
BS24	Pipistrella sp.	Male	Adult	Live

filtered through 0.22 µm filter (Millipore) and 280 µL of the filtrate was used for DNA extraction using commercially available QIAamp DNA stool Mini Kit (Qiagen, Valencia, CA, USA).

Total genomic DNA was also isolated from tissue samples using the DNAeasy Tissue Kit (Qiagen, Valencia, CA, USA) according to the manufacturer's instructions. The mitochondrial gene Cytochrome c oxidase I that target 202 bp were amplified using a forward sequence and reverse sequence of 5'-GTHACHGTCYCAYGCHTTYGTAATAAT-3' and 5'-CTCCWGCRTGDGCWAGRTTCC-3' respectively. PCR was performed using reaction volume containing 12.5 µL MasterMix with loading dye (Dream Taq green PCR master mix (2X), ThermoFisher), 10 µL sterilized distilled water, 1.5 µL extracted DNA (approximately 20 ng µL⁻¹), and 0.5 µL forward and reverse primers (10 µM). The PCR protocol included an initial denaturing step at 95 °C for 3 min, followed by 35 cycles of 95 °C for 1 min, 52 °C for 1 min and 72 °C for 1 min with a final extension at 72 °C for 10 min. The amplified DNA fragments were resolved on a 1.0% (w/v) agarose gel (1 × Tris Acetate-EDTA buffer), stained with ethidium bromide and visualized with UV light (Gel Logic 212 PRO, Care-stream Health, Inc.). The amplified product was purified by using DNA extraction kit (GeneJET™ Gel Extraction Kit, Fermentas) as per manufacturer's recommended protocol and sent for sequencing to Eurofins Genomics, India Pvt. Ltd, Bengaluru.

RESULTS

Species Identification

During the study period, five species of bats belonging to two families were identified among the study population. They are three species of fruit bats and two species of insectivorous bats identified from fecal DNA and also from the tissue of few collected bats by amplifying and sequencing of COI gene. The barcode sequences were analysed by BLAST search in GenBank. The bats species were identified as *Pteropus giganteus* (Brünnich, 1782), *Cynopterus sphinx* (Vahl, 1797), *Rousettus leschenaultia* (Desmarest, 1820), *Scotophilus heathii* (Horsfield, 1831) and *Pipistrellus coromandra* (Gray, 1838). All the COI sequences were deposited in GenBank under accession no MH910622, MH910623, MH910624, MH910625 and MH910626, respectively.

A total of 24 bats were collected during study period including dead, electrocuted and live bats which had fallen on ground or were injured. The body weight and body measurements of these bats were recorded and species was identified. The details of morphometry of the bats that were used for species identification, are presented in the Table 2.

Ecology

The roost searches were carried out to find out the roosting ecology of the bats and the following roost and foraging location and characteristics were recorded (Table 3).

In this study, *Pteropus giganteus* was found to be largest in size compared to all other bats with a body weight of 550 to 825 g and a wing span ranging from 108-125 cm. They are nocturnal animals having longer snouts, larger eye sockets and smaller ears, giving them a more dog-like appearance (flying foxes). Aina, Rupapur villages and Bareilly cantonment areas are the common roosting places for pteropus bats seen in study area (Figure 2), In Rupapur village and in Bareilly cantonment area (roosting places) these bats were found to colonize in hundreds during August and on a visit in January next year the population was found reduced. In roosting areas especially in Rupapur village during day time, they fan their wings and make lot of noise where they collectively hang upside down on their roosting trees like Eucalyptus and Sirius tree (*Albizia lebeck*) (Figure 3). During field surveys, in roosting places at sunset time, some bats start circling over roosting tree and nearby trees and as time advanced, their movements also increased with loud noises and almost all of them left for foraging within one hour after sunset. The movement of these *Pteropus* bats was governed by food sources. They flew continuously for long distances with varying height, depending on topography. *Pteropus* bats from Rupapur village often visited the IVRI campus for foraging on different fruits, especially Ficus, mahua, leechi which are found in various locations in the campus (near Kendriya Vidyalaya (KV), in front of Germplasm centre building and PM house). It was noticed that they start back to roosting places after foraging just before the dawn. Usually between 3.00AM to 4.00AM, these bats were found flying back to their roost and at around 5.00-6.00AM all the bats were back to their roost. From the faecal samples and spit out material collected in roosting places, it was evident that they extract the pulp of the fruits, vegetables and also

Table2. The list of bats identified during study period and its morphometry in cm

Morphometry	<i>Pteropus giganteus</i> (n=13)	<i>Rousettus leschenaultii</i> (n=1)	<i>Cynopterus sphinx</i> (n=2)	<i>Pipistrellus coromandra</i> (n=6)	<i>Scotophilus heathii</i> (n=2)
BW(g)	550-825 (719.6±80.2)	76	49-54	5-7 (5.93±0.66)	28-33
HBL	22-31 (26.76±2.86)	7.5	7.5-8.6	4.5-5.6 (5.06±0.39)	7.5-8
HF	5-6.5 (5.78±0.49)	1.7	1.2-1.6	0.6-0.8 (0.69±0.07)	1.0-1.2
TIB	7.2-8.3 (7.73±0.377)	3.2	2-2.3	1.2-1.4 (1.28±0.07)	1.9-2.2
FA	12.8-15.4 (14.16±0.88)	7.5	6.4-6.8	2.8-3.3 (3±0.16)	6-6.1
WSP	108-125 (116.1±5.63)	84	66-68	18-22 (19.75±0.63)	32-34
TL	1.8-2.1 (1.95±0.10)	1.5	1.2-1.3	9.5-11 (10.25±0.42)	0.5-0.6
2Mc	10.5-12.1 (11.23±0.52)	5.3	4.5-4.8	2.4-2.6 (2.5±0.07)	3-3.6
3Mc.1p	9.3-11 (10.23±0.62)	3.3	2.2-2.4	0.9-1.2 (1.03±0.95)	1.1-1.8
3Mc.2p	10.4-11.7 (11±0.41)	4.0	3.5-3.8	1.2-1.5 (1.4±0.12)	1.4-2
4Mc.1p	9.7-10.3 (9.93±0.18)	2.9	2.8-3.0	ND	1.4-1.8
4Mc.2p	5.3-6.5 (5.3±0.37)	3.0	2.1-2.3	ND	1.0-1.2
5Mc.1p	9.8-12.5 (11.1±0.85)	2.5	2.8-2.9	ND	1.0-1.3
5Mc.2p	4.7-5.9 (5.29±0.36)	2.1	2.6-2.7	ND	0.9-1
Ear	1.8-3.5 (2.77±0.59)	1.8	1.2-1.5	0.7-0.9 (0.8±0.09)	1.5-1.8
Tail	NA (2.15±0.13)	NA	NA	2-2.3	4.5-5.3

Abbreviations: BW: Body weight measured in gm; HBL: head and body length; HF: hindfoot length; TIB: length of tibia; FA: forearm length; WSP: wing span; TL: Thumb length; 2Mc: length of second metacarpal; 3Mc: length of third metacarpal, 3Mc.1p: first phalanx of the third metacarpal, 3Mc.2p: second phalanx of the third metacarpal; 4Mc: fourth metacarpal; 4Mc.1p: first phalanx of the fourth metacarpal; 4Mc.2p: second phalanx of fourth metacarpal; 5Mc: fifth metacarpal; 5Mc.1p: first phalanx of the fifth metacarpal; 5Mc.2p: second phalanx of fifth metacarpal, NA: Not Applicable, ND: Not Done

forages on leaves of those trees. These roosting places noticed were permanent over the years for these bats but their number seems to be reduced during winters, perhaps due to shifting to hibernation roosts. Usually the females give birth to one young in a year after a period of 6 month gestation. In one injured bat we found both the uterine horns were enlarged. One horn carries completely developed foetus and other one was having macerated foetus. The females were observed pregnant

during February to April. Second most abundant species studied was *Cynopterus sphinx*, which occurred within the campus (JDR, OCBII & OCBIII).

These bats are of medium size with a body weight of 49-54g, long snout, paler silky and fine fur. This species is differentiated from the *Rousettus leschenaultii* by its white edged wing bones and ears (Figure 4). A total of 12 colonies were noticed during the study period in which 9 colonies were seen inside cylindrical

Figure 2A. *Pteropus giganteus* seen at Bareilly cantonment areaFigure 2B. *Pteropus giganteus* seen in Aina village

Table 3. Roost location and roost characteristics of study population.

S.N	Roost location	Tree species	Species of bat	No. of groups /harem (roosting density)	Number of occupants per group
1	IVRI Campus				
1.1	OCB-II	White fig (<i>Ficus virens</i> / <i>Ficus infectoria</i>)	<i>Cynopterus sphinx</i>	Roosting area (3 groups)	4-5
1.2	OCB-III	White fig (<i>Ficus virens</i> / <i>Ficus infectoria</i>)	<i>Cynopterus sphinx</i>	Roosting area (3 groups)	3-4
1.3	Kendriya Vidhyalaya (KV)	Mahua tree (<i>Madhuca indica</i>)	<i>Pteropus giganteus</i>	Foraging area (2 group)	20-30
1.4	NEAR CARI	Banyan fig (<i>Ficus bengalensis</i>)	<i>Cynopterus sphinx</i>	Roosting area (3 groups)	3-4
1.5	Jt Director Research JD®	White fig (<i>Ficus virens</i> / <i>Ficus infectoria</i>)	<i>Cynopterus sphinx</i>	Roosting area (3 groups)	5-6
1.6	Germplasm Centre	Mahua tree (<i>Madhuca longifolia</i>)	<i>Pteropus giganteus</i>	Foraging area (2 group)	20-30
1.7	Postmortem (PM)	Banyan fig (<i>Ficus bengalensis</i>)	<i>Pteropus giganteus</i>	Foraging area (2 group)	25-30
1.8	Pathology Experimental Animal Shed	Grooves on building	<i>Scotophilus heathii</i>	Roosting area	-
1.9	Modular Lab Building	Grooves on building	<i>Pipistrellus coromandra</i>	Roosting area (3 groups)	6-8
2	Bareilly Cantt.	Eucalyptus (<i>Eucalyptus tereticornis</i>) and Siris tree (<i>Albizia lebbeck</i>)	<i>Pteropus giganteus</i>	Roosting area (4 groups)	250-500
3	Rupapur village	<i>Ficus insipida</i> , <i>Ficus religiosa</i> , Eucalyptus (<i>Eucalyptus tereticornis</i>) and Siris tree (<i>Albizia lebbeck</i>)	<i>Pteropus giganteus</i>	Roosting area (3 groups)	350-500
	Aina village	<i>Ficus insipida</i> , <i>Ficus religiosa</i>	<i>Pteropus giganteus</i>	Roosting area (3 groups)	200-300



Figure 3. *Pteropus giganteus* seen hanging on Sirius tree at Rupapur village



Figure 4. *Cynopterus spinx* colony seen inside the grooves of *Ficus virens* tree trunk in front of JD(R)



Figure 5A&B: *Cynopterus spinx* colony seen in the outdoor lamp shades hanging on *Ficus virens* inside IVRI campus

outdoor lamp shades hanging on trees and three in the groove of tree trunks. They seemed to colonize as a cluster of 5-7 bats in the outdoor lamp shades hanging on trees as well as in the crevices of the trees in these localities (Figures 5A & B). A fall in the number of bats of this species was noticed during the study period esp. in winter time. Like the *Pteropus* species, its movement was noticed after dusk and after foraging they returned to the roosting site before dawn. The materials spitted out by these bats usually contained seeds (guava, based

on seasonal availability) and feces appeared as dark ink like staining on the paper spread on the ground for sample collection in the roosting areas. The *Rousettus* sp. was found roosting on the ceilings of some abandoned buildings in the campus premises and shares the foraging trees along with other frugivorous bats (Figure 6). During flight females carries their young ones along with them. We got one such sample in a fish net placed across the fish pond.



Figure 6. A fulvous bat fruit bat (*Rouesttus Leschenaultii*) foraging on a guava tree at night



Figure 7. An insectivorous bat (*Pipistrellus comorandra*) captured from a wall crevice having broad muzzle, pale ventral part and oval shaped ears with folds at middle and presence of an ectoparasite on left ear flap.

The insectivorous bats identified in the study area were *Pipistrella coromandra* (Indian pipistrella) and *Scotophilus heathii*. *Pipistrella coromandra* is a very small bat ranging in wing span length of 1.8-2.2 cm and a body mass of 5-7g. It has a broad muzzle, dark brown dorsal and a paler ventral part (Figure 7). The ears were round to oval with folds in middle edge. In our campus we identified this species of bats in the cracks and crevices of walls and old ceilings in hostel. In evening its foraging was noticed very early compared to other bat species i.e around 5.00-5:30 PM in winters and 6:30-7.00 PM in summers. It has a different pattern of flight with a jerky movement, while feeding on insects mainly mosquitoes in the beginning of summers and small moths, insects in winters was observed. Following rain/showers insects attract to light also attract these bats for feeding. Some bats which we got in the month of March, from grooves in wall of house were pregnant with twins. They were seen as a maternity colony, 5-6 pregnant females with both horns pregnant.

One female *Scotophilus heathii* was found on the ground near the Experimental animal shed in the campus. The bat was found very weak and after some time it was dead and this specimen was used for species identification. Its external features like robust head, absence of yellow coloured ventral plumage, sheathed tail and body measurements suggest the species was *Scotophilus heathii* (Figure 8). It was confirmed by amplifying and sequencing *mtDNA*, Cytochrome Oxidase I gene. Since this species is insectivorous, they were usually noticed in the evening moving near street lights



Figure 8. A moribund insectivorous bat (*Scotophilus heathii*) found on the ground near the experimental animal shed on the campus

to catch its prey. Following rain/showers, insects are attracted to light and hence these bats come out in large number for feeding on them. Compared to *Pipistrella* bats, during foraging time the flight height from ground of these bats was very less and sometimes they moved very close to humans.

DISCUSSION

The bats from IVRI campus and adjoining village comprised of three frugivorous and two insectivorous species. *Pteropus* sp. was the most abundant frugivorous bat found with 3 roosting and 3 foraging areas. Earlier study in Uttar Pradesh revealed that *Pteropus giganteus* is the most widely distributed bat species in the state (Kumar et al. 2016). The study area was populated with different species of Fig trees, Kopak, Eucalyptus, Leechi, Mahua trees and other flora which provide a suitable habitat for this species. Previous studies revealed that selection of a site for roosting is highly influenced by their food resources and their ability to feed on a variety of plant species throughout the year (Hahn et al. 2014, Pierson and Rainey 1992). Pit is also documented that *Pteropus* bats forage and roost on certain tree species such as *Ceiba pentandra* (kapok), *Durio zibethinus* (durian), *Ficus* sp.(fig), *Mangifera indica* (mango), *Manilkara zapota* (chicle), *Musa* sp. (wild banana), *Ochroma lagopus* (balsa) and *Eucalyptus* sp. (Nathan et al. 2005). Compared to other *Pteropus* bats, the *Pteropus giganteus* keep their roosting and foraging site different (Pierson and Rainey 1992). *Pteropus* sp. were abundant in the past in south-east Asian countries, but for bush meat and for their medicinal values they were hunted, causing a decline in their number (Mildenstein et al. 2005). The habitat of these bats depends on the tree species availability, human disturbances and seasonal fluctuations. The decline in the number of bats in our study area on January 2017, compared to August, 2016 may be due to seasonal change. During winter periods tree roosting bats prefer hibernation roosts compared to cave roosting bats (Turbil 2008). Similar kind of decline in *Pteropus* bats were noticed in a study in Himachal Pradesh due to seasonal variation (Saikia et al. 2011). The complete external measurements of *Pteropus giganteus* were recorded in this study and it falls within the range of earlier available literatures (Saha et al. 2015). The wing span is large and it accounts for the chance of increase in electrocution during the flight hours, since most of the *Pteropus* specimens collected during the study period were electrocuted ones.

Cynopterus sphinx (Vahl) noticed in the study locality is gregarious; a group of 5-8 bats were noticed always. Out of seven species of *Cynopterus* noticed, *Cynopterus sphinx* is the most common species in Indian subcontinent (Simmon 2005). The external body measurements of both *Cynopterus* and *Rousettus* were almost found similar, but the zygomatic arch was found

robust and the skull was ovoid in *Cynopterus* (Salim 2018). This bat is well known to use six species of trees such as mast tree (*Polyalthia longifolia*), curtain creeper (*Vernonia scandens*), Palmyra palm (*Borassus flabellifer*), areca palm (*Areca catechu*), kitul palm (*Caryota urens*), banyan tree (*Ficus bengalensis*), and banana (*Musa paradisiaca*) for its diurnal roosting (Rajasekar et al. 2006). In this species, it was found that the odour cue is more important for their feeding behavior (Zhang et al. 2014) that could be the reason for frequent visits of these bats on guava trees based on seasonal availability. The only frugivorous bat found in India with echolocating ability is *Rousettus*. They were usually seen in old buildings and monuments (Kumar et al. 2015; Vanitharani 2006). Earlier study in Uttar Pradesh showed that both the sexes of this bat live separately, except during the breeding time in October to March (Krishna and Dominic 1985). Unfortunately, we couldn't able to study much on the habitat of this species due to less number of individual bats in our study area. Also these bats prefer dark roosting places and they won't come out during day time, which also reasons for loss of habitat study. The morphometry of the available specimens were found within the range recorded by Kumar et al. (2015) and Bates and Harrison (1997). The two species of insectivorous bats identified in the study comes under the family Vespertilionidae. *P. coromandra* or Indian pipistrella are the least concern bats with in Indian subcontinent. These bats were more active during evening times and the activity gets reduced at night (Saikia et al. 2011). These bats live close to human environment, seen as in colonies and in our study we observed a maternity colony. The maternity colonies consist of couple to dozen of pregnant females with usually twins (Arlettaz et al. 2000). The breeding time is usually recorded. It was found difficult to distinguish the different species of *Pipistrella* by its morphometry alone. In this study the morphometry of the captured specimen lies between the range observed by Saha et al. 2015 and Bates and Harrison 1997. Also further confirmation was done by the PCR based method and sequence analysis showed 96% identity to the *Pipistrella coromandra* sequences in NCBI. Another insectivorous bat observed was *Scotophilus* spp. Mainly, two species of *Scotophilus*, *S. kuhli* and *S. heathi* were recorded in Indian subcontinent. These species roost mainly on ceilings of old man made buildings and in trees (Dookia and Mishra 2018). In this study one specimen was found dead on the ceiling of animal shed and another one was found lying on the ground near the animal shed. Fecal sample

analysis revealed that these bats feed on a wide range of insects of order Diptera, Hymenoptera, beetles and leeches (Srinivasalu et al. 2010). The external descriptions and measurements of these two specimens and sequence analysis of PCR amplicons showed 98% identity with *Scotophilus heathi*.

CONCLUSION

Bats are the second largest group of mammals globally next to rodents. This paper documents the diversity of bat species present in and around Bareilly city of Uttar Pradesh. A non-invasive approach of sample collection was useful for species identification without killing of bats. Suitable roosting and foraging places were needed for the successful life and survival of bats. Good foraging places with sufficient food and water besides dark roosting places such as grooves on trees, man-made structures like buildings, artificial lights etc. are preferred by these bats. Availability of these requirements in the campus attracted the large frugivorous bats from nearby places in the outskirts of Bareilly city and the insectivorous bats have plenty of roosting sites in the campus where many farm animals are housed and the land is cultivated for fodder, and grains. More systematic and intensive survey on different bat species is needed.

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