

# Behavioural ecology of the lesser mouse-tailed bat, *Rhinopoma hardwickii*

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## *Abstract*

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Bats are the second largest group of mammals after rodents. They come under the mammalian order Chiroptera which divided into two sub orders, Megachiroptera and Microchiroptera. Approximately 119 species of bats found in India, out of which 14 species belong to fruit-eating (Megachiropteran) and rest are insect-eating bats (Microchiroptera). Rhinopomatidae is a monotypic family with a single genus, *Rhinopoma*, with only four known species such as *R. hardwickii*, *R. microphyllum*, *R. muscatellum* and *R. macinnesi*. *Rhinopoma hardwickii* commonly known as lesser mouse-tailed bat.

*Rhinopoma hardwickii* distributed in arid and semi-arid region. *Rhinopoma hardwickii* adapted to live in abandoned buildings, caves, rocky areas, dry scrub, and walls of deep well. They prefer to roosting in rocks, cracks and crevices of large rocks during hot summer. They undergo torpor in winter. They live in small group consist of 4-10 individuals to large colony consist many hundreds to thousands individuals.

*Rhinopoma hardwickii* is a primitive echolocating bat. It produces at least three different types of sounds: emits FM-sound while approaching an obstacle and CF sound in the open area. There are many factors responsible for call structure variability such as age, individual identity, foraging mode, flight situation, presence of conspecifics, acoustic clutter and ambient noise.

Bats are voracious in nature and feed on large scale of insects in a night with the help of echolocation. Insectivorous bats are the primary consumers of many nocturnal insects. They prey on variety of agricultural insect pests such as tobacco budworms,

corn borers, plant hoppers and oriental armyworms. A very few studies have been carried out on the diet selection of *R. hardwickii*. However, no detailed report available on diet composition and diet selection of *R. hardwickii* on seasons and habitats in India. Earlier studies on reproductive behaviour of *R. hardwickii* were carried out by capturing and dissecting the bat, which is against the law of conservation.

Therefore, the aim of this study was to observe roosting, feeding, reproductive and echolocation behaviours of *R. hardwickii*.

Bundelkhand region is large arid zone of Uttar Pradesh India. *Rhinopoma* species restricted to only arid and semi-arid regions, therefore, the distribution, roosting, reproduction and echolocation and wing morphology of *R. hardwickii* were investigated without disturbing them. I also accessed the diet composition to know about their importance in ecosystem. *Rhinopoma hardwickii* comes under least concern category of IUCN, so it is necessary to study behavioural ecology of *R. hardwickii* for their conservation.

### **Distribution of lesser mouse-tailed bats in arid zones of Uttar Pradesh**

*Rhinopoma hardwickii* found in old building, monument, caves, fort, wall of deep wells. Periodical field surveys were carried out from February 2019 to August 2021 at residential and non-residential areas of Hamirpur, Jalaun, Chitrakoot, Lalitpur, Mahoba, Banda, and Jhansi along with forest, hill, agriculture land & terrain to assess the distribution of bats. The population of roosts was accessed by photographic count.

A total of 36 roost sites of eight species of bats were explored, out of which 16 roosts were occupied by *R. hardwickii*. The characteristic features of *R. hardwickii* forearm,

which is smaller than tail. The pelage colour was dark grey. The ears possess small tragus with eight transvers line. Body mass and body head length was higher in females than the males. Forearm of male was also higher than female. *Rhinopoma hardwickii* was mainly found in arid zone roosting only in fort, historical monument, old temple, abandoned house and cave. They were observed in attic of roost, crevices and holes. The colony size ranged from, small group to hundreds of individuals, depend upon roost quality and area of roost.

Highest population was found in Jhansi fort while lowest population was found Gupt Godavari (Chitrakoot). Male and female bats roost together and shared the roost with *T. nudiventris* and *R. microphyllum*. A peculiar pattern was observed that they prefer roosting mainly where water source was available adjacent to their roosts. Mostly roost of *R. hardwickii* found away from the human colony and inner most of the building where light intensity was zero lux. In most cases the roosts were surrounded by forest, agriculture land, water bodies, human colonies and hill rocks.

Besides *R. hardwickii*, seven other species such as *Rhinopoma microphyllum* (Rhinopomatidae), *Megaderma lyra* (Megadermatidae), *Taphozous nudiventris*, *T. perforatus* (Emballonuridae), *Scotophilus heathii* (Vespertilionidae) and *Rousettus leschenaulti*, and *Pteropus medius* (Pteropodidae) were recorded. All above mentioned species were found roosting in monument, abandoned buildings, caves, temple and abandoned house except *P. medius*.

Shannon diversity index of Bundelkhand regions was 1.113 and Evenness index was 0.533. The most abundant species in Bundelkhand region was *R. microphyllum* (62.73%), followed by *R. leschenaultii* (10.69%), *R. hardwickii* (8.00%), *P. medius* (7.25%), *T. perforatus* (6.90%), *T. nudiventris* (3.50%), *M. lyra* (0.53%) and *S.*

*heathii* (0.372%) while widely distributed species in Bundelkhand was *R. hardwickii* and least distributed species was *M. lyra* and *S. heathii*. The survey indicates that these bat species were unevenly distributed across the Bundelkhand region (Evenness index 0.53); it may be due to degree of protection or resource availability.

The distribution of *R. hardwickii* was mainly affected by the presence or absence of food, climatic condition, water source etc. The occurrence of *T. perforatus* was first time reported from Uttar Pradesh. A peculiar pattern was observed that they prefer roosting nearby water source. Bats were roosting in attic and crevices of building, monuments and caves where height of most of the roost from the ground was more than 14 feet and temperature of roost was almost stable ( $28.62 \pm 1.51$  °C). Those roosts where temperature fluctuates with environment, bats vacate the roost in winter and return back when temperature becomes normal.

**Diet composition and diet choice of lesser mouse-tailed bat, *Rhinopoma hardwickii* (Gray, 1831)**

Field surveys were carried from March 2019 to February 2020 at arid zones of Bundelkhand (i.e., Hamirpur, Lalitpur, Jalaun and Jhansi) and adjacent districts (i.e., Lucknow and Barabanki). Guano samples were collected from the roost sites by spreading 2 x 2 m polythene sheet beneath the roost. In addition, the bats were captured using mist net, each individual was kept in a cotton bag until defecation, thereafter they were released at the site of capture. Fresh faecal pellets were collected seasonally, i.e., summer (March – June), monsoon (July – October) and winter (November – February). Guano samples were kept in sample vials and stored at -20°C until analysis. Each intact pellet was soaked and dissolved in distilled water, teased gently using a fine brush and the insect remnants were separated using forceps. The

recognizable insect body parts like legs, antennae, wings and mouth parts were separated and photographs were taken under stereo microscope using Digital Camera. Each insect remnant was identified to its lowest rank as much as possible. The identified remnants of different sites were grouped into legs, antennae, wings, and mouth parts and the frequency of occurrence was obtained.

A total of 61 pellets of 10 sites yielded 1035 remnants of insects. The highest percentage of remnants belongs to legs, followed by wings, antennae, abdominal segments and mouth parts. The remnants belong to eight insect orders such as Coleoptera, Hemiptera (sub-orders Heteroptera and Homoptera), Orthoptera, Hymenoptera, Dermaptera, Diptera, Lepidoptera and Plecoptera. The remnants of sub-order Homoptera showed the highest frequency of occurrence followed by orders Coleoptera, Orthoptera and Hymenoptera and these four orders of insects constitute major portion of the diet of *R. hardwickii*. The orders Dermaptera, Diptera, Lepidoptera and Plecoptera contributed a small proportion in the diet of *R. hardwickii*. The remnants of orders Lepidoptera and Plecoptera were occasional. However, there was no significant difference observed in the occurrence of remanence of various insect orders in ten different roost sites, Coleoptera ( $\chi^2 = 0.800$ ,  $p = 0.999$ ), Heteroptera ( $\chi^2 = 0.788$ ,  $p = 0.990$ ), Orthoptera ( $\chi^2 = 4.50$ ,  $p = 0.342$ ), Hymenoptera ( $\chi^2 = 0.330$ ,  $p = 0.563$ ), Diptera ( $\chi^2 = 1.00$ ,  $p = 0.317$ ), Lepidoptera and Plecoptera ( $\chi^2 = 0.00$ ,  $p = 1.00$ ). The result of current study shows that the food choice of *R. hardwickii* did not differ significantly across roost sites, while differed seasonally. Further, it reveals that the lesser mouse-tailed bat acts as potential and natural insect balancing agent.

The results of present study show that the lesser mouse-tailed bats consumed insects belong to eight insect orders across the geographical locations and seasons. The most

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preferred food items belong to order Coleoptera followed by Heteroptera and Orthoptera and least preferred items belong to orders Dermaptera, Diptera, Lepidoptera and Plecoptera. Heteropteran insects were the second commonly found food items and contributed 30.4% of the diet of *R. hardwickii*. The diet selection of many insectivorous bats depends upon dental and cranial morphology, wing shape, and echolocation call. The results of faecal pellet analysis revealed that the legs and wings constituted more than 74% of remnants isolated, while antennae, abdomen, and mouth parts contributed less than 15%. The highest percentage of legs and wings was found in the isolated remnants probably due the composition of chitin in legs and wings.

**Roosting and reproductive behaviour of lesser mouse-tailed bat, *Rhinopoma hardwickii* (Gray, 1831)**

Roosting and reproductive behaviours are major contributors to the evolutionary success of organisms and are subject to many evolutionary forces. For assessing roosting and reproductive behaviour medium size colony was captured using hoop-net. The gender and colony compositions were assessed; morphometric parameters such as forearm, hind arm, body weight, head-body length etc. were taken for species identification. Infra-red CCTV camera was installed beneath the roost to assess roosting and reproductive behaviours. Play-back analysis was performed using VLC media player, and the behavioural patterns were analysed.

*Rhinopoma hardwickii* sparsely roosted during summer while clumped during winter season. Male and female preferred to roost together, but lactating female roosts separately during lactation. A colony consist of 15 individuals were video graphed using CCTV camera during October. The colony composed of 6 females, 3 pups, 5

sub-adults and 1 adult male. The female was larger than male; however, the forearm length of male was higher. A total of 61 social and general behaviours recorded in which general behaviours were most frequent across the seasons while social behaviours such as Territorial behaviour, Courtship behaviour and Mother - infant and juvenile behaviour occurred only during specific months. They undergone breeding once in a year (February to March) just after winter dormancy, and after three months of gestation, a single pup was given during June - July. Pups weaned from mother after two months of lactation. The results of current study revealed that *R. hardwickii* preferred monuments, caves and abandoned building, as their roost site. They undergone mating during spring and parturition at monsoon when insects were abundant.

*R. Hardwickii* vacated the roost where the roost temperature reached less than 20 °C. *Rhinopoma hardwickii* was formed heavy clump during winter season to avoid cold. *Rhinopoma hardwickii* follow annual reproductive cycle. There were two type behaviours observed, the general behaviour and reproductive behaviour. The frequencies of behaviours differed with seasons. General behaviours occurred in all months with little difference in their frequencies while reproductive behaviour found only reproductive season; this pattern clearly indicates that *R. hardwickii* change its behaviours according to season. Total 61 behaviours were found in which 12 behaviours such as circling, approach, scruff-bite, uro-genital lick, grasp-restraint, face-reject, vocalization, intromission, copulation, push away, aggression and break associated with courtship. While turn, sway alert, move away, hang relax, hang alert, swivel, wing drop, hang tense and hanging associated with roosting behaviours. They were important behaviour in respect to reproduction. Reproductive behaviour found

only in reproductive season, so *R. hardwickii* changes their behaviour in reference to season and reproduce once in a year. They produced only single young in a birth.

**Wing morphology and echolocation of lesser mouse-tailed bat, *Rhinopoma hardwickii* (Gray, 1831)**

The bat was placed on its ventral side over a large graph paper, extended the wings with the leading-edge perpendicular to the body axis, traced the wing outline and the wing area was assessed. The length of arm wing (cm) and hand wing (cm), area of arm wing (cm<sup>2</sup>) and hand wing (cm<sup>2</sup>), wing span (cm) and wing area (cm<sup>2</sup>) were measured. Wing loading (WL), aspect ratio (AR), and tip shape index (TSI) were calculated. Relative wing loadings (RWL) were calculated. The echolocation calls were recorded at three different sites: 1) Roost, Field and Capitative. Data analysis was carried out using SPSS 21.0 (SPSS Inc, USA).

A total of 41 individuals (27 male and 14 female) of *R. hardwickii* were captured using hoop net as well as mist net from their day roost. There were no statistical significance differences in arm wing length, arm wing area, hand wing length, hand wing area, aspect ratio, tip length ratio, and wing loading among the sexes ( $p > 0.05$ ). Therefore, we pooled the wing morphology data of males and females. The average wing loading of *R. hardwickii* was  $11.92 \pm 1.87$  (N/m<sup>2</sup>) while aspect ratio was  $7.04 \pm 0.44$ . The relative wing loading of *R. hardwickii* was  $8.41 \pm 5.57$ . The tip length ratio and tip area ratio were  $0.68 \pm 0.04$  and  $0.44 \pm 0.05$  respectively. The tip shape index was  $1.57 \pm 0.15$ .

The calls of *R. hardwickii* consisted up to five harmonics of FM and CF- FM sweeps, but four harmonic calls were common. The second harmonic was the most intense with a peak frequency of 28.3 to 36.9 kHz. The start frequency ranged 26.5 – 38.8

kHz ( $32.15 \pm 2.84$  kHz) while end frequency ranged 24.1 – 38.7 kHz ( $31.29 \pm 3.71$  kHz). The pulse interval was  $39.92 \pm 46.86$  ms. When compared start, end and peak frequency as well as IPI of three different habitats as roost, capitative and field recording, we found that there were highly significant differences at three different habitats ( $p = 0.001$ ).

### **Conclusion**

*Rhinopoma hardwickii* is a small sized free tailed bat, which roost in arid and semi-arid regions. *R. hardwickii* was widely distributed in Bundelkhand region. They roost in abandoned building, house, monument and caves, where light penetration was zero lux. They mainly feeds upon Coleoptera, Hemiptera (sub-orders Heteroptera and Homoptera), Orthoptera, Hymenoptera, Dermaptera, Diptera, Lepidoptera and Plecoptera order insect. *R. hardwickii* was show uniqueness like *R. hardwickii* only small bat which feed in cluttered environment and mostly in agriculture field while other same sized bat feed in open field. They also perform very crucial role in ecosystem as insect pest controlling agent. Rhinopoma is a monophyletic group with laryngeal echolocation property. In comparison to other small bat, they have more complicated echolocation. They emitted echolocation call of multiple harmonics while other same sized bat emitted one or two harmonic echolocation call. Their call little bit differs in different habitat such as in captive, field and roost they emitted four to five harmonic calls with  $32.83 \pm 2.13$  kHz,  $30.04 \pm 0.81$  kHz and  $32.76 \pm 0.87$  kHz peak frequency respectively. They show adoptability to environment and shows various adaptations such as winter dormancy and annual reproductive cycle. *Rhinopoma hardwickii* undergone breeding once in a year and gave only single pup in a birth.

**Recommendation:** *Rhonopoma hardwickii* perform a crucial role in ecosystem as insect pest controlling agent and guano is a natural fertilizer. However due to various myths and activities the habitat of bats being destructed. So the population of *R. hardwickii* is declining day by day. It is our responsibility to conserve the bat for continuation of species and get the ecological benefits offered by bats.