

Roosting ecology, diurnal behaviour and threats of the Indian Flying Fox *Pteropus medius* in Kangra district, Himachal Pradesh, India

Diljeet Singh

Associate Professor, Department of Zoology, Government Arya Degree College Nurpur, Kangra, Himachal Pradesh, India

Abstract

The study on the Indian Flying Fox *Pteropus medius* (Temminck, 1825) was conducted from October 2025 to January 2026 in the Kangra district of Himachal Pradesh, India. The research was carried out at two primary sites, Kotla and Jassur, during the autumn and winter seasons to establish baseline data on habitat preference, diurnal behaviour, population dynamics and environmental threats. Using the direct roost count method, observations were recorded during the daytime (08:00 - 17.30). Data revealed a higher population during autumn compared to winter across both sites. The bats occupied an average of 23 roosting trees. Kotla colonies exclusively utilized *Eucalyptus tereticornis* (n=11; mean height: 27.9 m, range: 25–30 m; mean DBH: 35.4 cm, range: 22–42 cm), whereas Jassur colonies occupied both *Eucalyptus tereticornis* (n=6; mean height: 31 m, range: 28–35 m; mean DBH: 61.2 cm, range: 52–71 cm) and *Populus deltoides* (n=6; mean height: 23.8 m, range: 20–26 m; mean DBH: 44.6 cm, range: 42–47 cm). Individual tree occupancy ranged from 6 to 52 individuals. Activity levels fluctuated significantly throughout the day. Inactivity (resting) peaked in the early morning (80%), while active behaviours were most prevalent during late morning (45%), followed by late and early afternoon. The most frequent activities observed were body movements, followed by wing movements, locomotion, vocalisation and social agonism. Resting and wing stretching were more frequent in winter, while wing flapping was more prevalent in autumn. Regarding posture, the majority of bats (75%) hung by their feet (one or both), while the remainder utilized various combinations of both feet and hands. The average duration of activities—such as grooming, posture changes, flapping, stretching, crawling, flight, vocalisation, fighting, courtship and elimination—varied from 2 -150 seconds. The primary threats to bats in this region included habitat destruction, human- or animal-induced disturbances, electrocution and accidental injuries.

Keywords: *Pteropus medius*, Indian Flying Fox, ecology, behaviour, threats, Kangra, Himachal Pradesh

Introduction

The Indian Flying Fox *Pteropus medius* (Temminck, 1825), is one of the largest bats in the world which forms large aggregations and colonies on trees ranging from a few hundred to a thousand individuals (Kunz 1982; Vyas and Upadhyay 2014; Manandhar *et al.* 2017; Mishra *et al.* 2019) [12, 23, 14, 16]. These bats inhabit large roosts close to human settlements, agricultural lands, water sources, orchards, highways, rural or urban areas and forests (Pandian and Suresh 2021; Masood *et al.* 2024) [17, 15]. They prefer roosting on large and tall trees with dense canopy and sufficient surface area for colony protection (Gulraiz *et al.* 2015; Kumar and Elangovan 2019) [6, 9]. Day roosts provide an essential environment for various behavioural activities including resting, sleeping, grooming, social interaction, communication, mating, digestion, excretion and protection from adverse environmental conditions and predation (Kunz 1982; Koju and Chalise 2010; Kumar *et al.* 2017; Devi and Kumar 2024) [12, 8, 11, 4]. The diurnal behaviours of these bats are further influenced by shifting weather conditions and seasonal changes (Roy *et al.* 2020; Anjum *et al.* 2024; Devi and Kumar 2024) [21, 1, 4]. Major threats to their survival include hunting for meat, habitat loss, the uprooting or felling of roost trees, construction activities, electrocution, pollution and urbanisation (Chakravarthy and Yeshwanth 2008; Prajapati *et al.* 2020) [2, 19].

In Himachal Pradesh, studies on the Indian Flying Fox have been conducted by some workers: Lindsay (1927) [13] in the Kangra (Gopalpur) and Kullu (Kotla- 940 m) districts; Ferrar (1934) [5] and Paul *et al.* (2009) [18] in the Kullu (Kullu)

district; and Saikia *et al.* (2011) [22] in the districts Bilaspur (Bilaspur-530 m), Mandi (Dharampur-630 m, Dodour-Nehr Chowk-760 m), Solan (Kunihar-960 m, Nalagarh-600 m) and Kangra (Nurpur-590 m). The recorded altitudinal range of the Indian Flying Fox across these sites in Himachal Pradesh varies from 530 m to 960 m. Despite the prior studies, fundamental information regarding the roosting ecology and behaviour of the species in several less explored regions of the state remained lacking; therefore, the present study was undertaken to fill these gaps.

Materials and Methods

a. Study Area

The two study sites, Kotla and Jassur, are located in the Kangra district of Himachal Pradesh, situated 27 km apart along the Kangra-Pathankot highway.

Kotla: This site is characterized by hilly terrain in the foothills of the Dhauladhar range, situated at an altitude of 590 m, with geographical coordinates N 32°14.715', E 076°03.151' (Figure I). The region experiences a subtropical climate with average daytime temperatures ranging from 19°C–30°C in autumn (October–November) and 7°C–18°C in winter (December–January). (Source: accuweather.com Kotla, Himachal Pradesh).

Jassur: This site is located in a valley between the Shivalik and Dhauladhar ranges at an altitude of 440 m, with geographical coordinates N 32°16.991', E 075°51.420' (Figure II). Similar to Kotla, it features a subtropical climate

with average daytime temperatures ranging from 20°C–32°C in autumn (October–November) and 5°C–17°C in winter (December–January). (Source: accuweather.com Jassur, Himachal Pradesh).

Both sites follow a seasonal cycle comprising summer (May–June), monsoon (July–August), and winter (December–February), with spring (March–April) and autumn (September–November) serving as transitional periods.

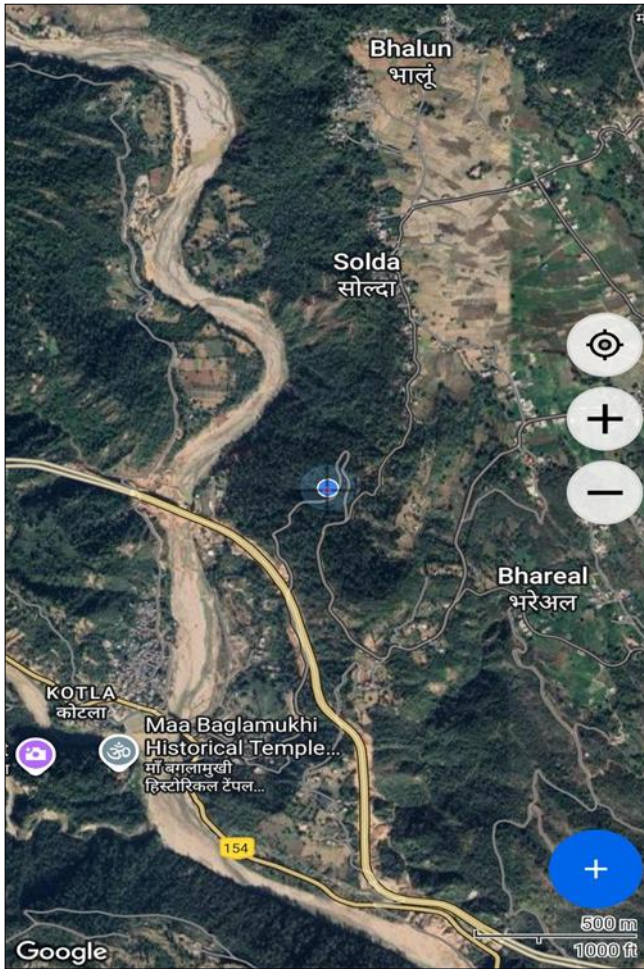


Figure I: Satellite map of study site Kotla (Source: Google Maps)



Figure II: Satellite map of study site Jassur (Source: Google Maps)

b. Methodology

Bat observations were conducted from October 2025 to January 2026, spanning the autumn and winter seasons. Two study sites, Kotla and Jassur, were monitored alternately with at least three visits per site each month. Observations were performed during daylight hours (08:00-17.30) using Celestron 16x32 binoculars and the naked eye; evidence was documented using a Nikon 16MP digital camera (83x zoom). Each survey session lasted for at least two hours or more during which colonies were scanned for general behaviours. These sessions were divided into Early Morning (8.00-10.00), Late Morning (10.00-12.00), Early Afternoon (12.00-15.00) and Late Afternoon (15.00-17.30) which were covered during rotating visits. Focal sampling was performed on randomly selected individuals for a minimum of five minutes or until the observed activity concluded. Colony size was determined via the direct roost count method during the daylight hours, with total populations calculated by summing individuals across all trees.

To record dendrometric data, tree height (H) and diameter at breast height (DBH) were measured using both a manual measuring tape and the “Trees” mobile application. DBH was recorded manually, while total height was estimated by extrapolating from a known lower section to the canopy; results from both methods were cross-referenced for

accuracy. Geographic coordinates, altitude and site area were recorded using a Garmin eTrex 32x handheld GPS. Species identification was verified using standard taxonomic literature and online biological databases.

Observations and Results

a. Site Description and Habitat

Kotla: Bat colonies inhabit a forested area in the rural locality of Latehar, near Kotla (Figure 1 a). This roosting site is located near water sources, human settlements, agricultural lands and gardens. Prominent villages and towns in the surroundings include Kotla, Solda, Jolna, Trilokpur and Bhedkhad. This site is bordered by local roads and is within 500 m of a highway, with several hilly streams located near Kotla (2 km), Trilokpur (3 km), Bhedkhad (3.5 km), and Jolna (4 km). Local agriculture primarily consists of wheat, rice, maize and vegetables, while gardens and orchards feature fruit trees such as mango, guava, citrus and others.

Jassur: Bat colonies inhabit an avenue plantation along the boundary wall of an office and the adjoining trees of an orchard in a semi-urban area of Jachh, near Jassur (Figure 1 b). According to local sources, these colonies have occupied this area for many years. The roosting area is surrounded by roads, water sources, human habitations, agricultural lands,

gardens and orchards. Prominent villages and towns in the surroundings include Jassur, Nurpur, Ganoh, Kandwal, Nagni, Bhadwar, Sadwan and Suliali. The site is bordered by an adjacent highway and numerous hilly streams, with proximity to Jassur (200 m), Ganoh (3 km), Nurpur (4 km), Badwar (7 km), Kandwal (8 km), and Suliali (10 km). Agricultural lands in the vicinity primarily cultivate wheat, rice, maize and local vegetables, while the orchards and gardens produce mango, guava, citrus fruits (kinnow, malta, lime, lemon), litchi, pear, peach, plum, berries, papaya and others. The orchard of the adjacent Regional Horticulture Research and Training Station, Jachh, contains fruit trees such as guava, mango, soapnut, pear and litchi. According to workers at this orchard, the bats have been observed feeding upon the fruits of these trees.

b. Roosting Tree Characteristics and Population Dynamics

Kotla: Bat colonies occupied Forest Red Gum *Eucalyptus tereticornis* trees within a forested area (Figure 1 c). These roosting trees were spaced 1.5 to 4.5 m apart (mean: 3 m) and distributed across an area of 8,200 m². The bats roosted at a minimum height of 24 m above ground level, showing a preference for the upper branches. The population peaked in October with 230 individuals across 11 trees (Table 1), while the lowest count was recorded in January with 190 individuals across 9 trees.

The height of the Eucalyptus trees (n=11) ranged from 25 m to 30 m (mean: 27.9 m) and diameter at breast height (DBH) ranged from 22 cm to 42 cm (mean: 35.4 cm) Table 1). Bat counts per tree varied from 8 to 52 (mean: 21) (Table 1). These results suggest that large sized trees provide more suitable roosting sites.

Jassur: Bat colonies occupied Forest Red Gum *Eucalyptus tereticornis* and Poplar *Populus deltoides* trees located along an avenue plantation and within an orchard (Figure 1 d). These roosting trees were spaced 1.0 m to 4.0 m apart (mean: 2.5 m) and distributed over an area of 1,150 m². Bats were observed at minimum heights of 19 m in Poplar and 24 m in Eucalyptus trees, typically occupying the upper branches.

The population peaked in October with 240 individuals distributed across Poplar (n=6) and Eucalyptus (n=6) trees (Table 2). Conversely, the minimum population was recorded in January, with 200 individuals occupying Poplar (n=4) and Eucalyptus (n=6) trees.

Poplar (n=6): Tree height ranged from 20 m to 26 m (mean: 23.8 m) and diameter at breast height (DBH) ranged from 42 cm to 47 cm (mean: 44.7 cm) (Table 2). Bat counts per tree varied from 6 to 50 (mean: 20) (Table 2).

Eucalyptus (n=6): Tree height ranged from 28 m to 35 m (mean: 31 m) and DBH ranged from 52 cm to 71 cm (mean: 61.2 cm) (Table 2). Bat counts per tree varied from 10 to 29 (mean: 19) (Table 2).

Across both species, tree height ranged from 20 m to 35 m (mean: 27.4 m) and DBH varied from 40 cm to 71 cm (mean: 52.9 cm). Bat counts per tree ranged from 6 to 50 (mean: 20). These results suggest a positive correlation between tree size and bat distribution.

At both the Kotla and Jassur sites, total bat counts were significantly higher in autumn than in winter. Population numbers on individual trees fluctuated frequently as bats shifted between roosts throughout the observation period. Consequently, the number of occupied trees varied from 9 to 12; bats were observed colonizing new trees in adjacent locations while simultaneously vacating older roosts.

Table 1: Height (H, m) and Diameter at Breast Height (DBH, cm) of Eucalyptus trees (n=11) associated with bat distribution at the Kotla site

Tree No.	Height (m)	DBH (cm)	Bat Count
1	28	22	8
2	30	31	20
3	25	29	15
4	28	32	22
5	25	36	20
6	28	37	18
7	30	40	52
8	30	41	25
9	29	42	15
10	29	42	20
11	25	37	15
Total	—	—	230
Mean	27.9	35.4	21

Table 2: Height (H, m) and Diameter at Breast Height (DBH, cm) of Poplar (n=6) and Eucalyptus (n=6) trees associated with bat distribution at the Jassur site

Tree No.	Poplar H (m)	Poplar DBH (cm)	Poplar Bats	Eucalyptus H (m)	Eucalyptus DBH (cm)	Eucalyptus Bats
1	23	44	15	28	52	16
2	23	46	12	28	62	10
3	20	42	6	30	68	29
4	26	47	50	30	71	25
5	26	44	25	35	56	18
6	25	45	14	35	58	20
Total	—	—	122	—	—	118
Mean	23.8	44.7	20	31	61.2	20

c. Foliage Preference and Behaviour

Observations indicated that 70% of the bats preferred trees with dense, leafy foliage, while the remaining 30% roosted on trees with sparse foliage or bare branches at both sites. At Kotla, bats exclusively occupied Eucalyptus trees during both autumn and winter; however, some individuals frequently shifted to adjacent Eucalyptus trees, abandoning older roosts, particularly during winter. At Jassur, although Poplar trees

began shedding leaves at the onset of winter in December; the colonies initially remained on the bare branches. As temperatures dropped in January, the majority of bats relocated to nearby Eucalyptus trees with denser foliage, by which time most Poplars were devoid of both leaves and bats. Frequent shifts between Eucalyptus and Poplar trees were observed throughout the study, appearing to correspond with changing seasonal and temperature conditions.

d. Diurnal Activity Patterns

Bats were observed hanging upside down (heads downward, feet upward) while gripping tree branches. They were either inactive (resting) or active—exhibiting behaviours such as body movements (grooming, posture changes), wing movements (flapping, stretching), locomotion (branch

crawling and flight), vocalisation and fighting. As summarized in Table 3, bat activity levels fluctuated throughout the day. The lowest activity occurred during the early morning (20%), while highest activity was recorded during the late morning (45%), followed by late afternoon (40%) and early afternoon (35%).

Table 3: Diurnal Activity Patterns

Time Period	Time Range	Active (%)	Inactive (%)	Observation Notes
Early Morning	08:00 – 10:00	20%	80%	Lowest activity; silent, with slight increases after sunrise.
Late Morning	10:00 – 12:00	45%	55%	Peak activity period.
Early Afternoon	12:00 – 15:00	35%	65%	Activity decreased slightly.
Late Afternoon	15:00 – 17:30	40%	60%	Activity rose again.

e. Colony Activity Dynamics

Bat activity levels varied significantly among colonies across different trees; some trees hosted a high percentage of active individuals, while others showed lower activity levels. Throughout the observation periods, the most frequent behaviours observed were resting, followed by body movements (grooming and posture changes), wing movements (flapping and stretching), locomotion (crawling and flight), vocalisation, fighting, excretion and courtship (Table 4). Activities such as grooming, posture changes, wing flapping, wing stretching, locomotion, vocalisation and fighting were observed throughout the day. In contrast, excretion (defecation or urination) was primarily observed during the morning (8:00–11:30) and courtship or mating behaviour occurred during the October–November months of the study period.

f. Weather and Seasonal Influences

Bat activity was significantly higher during mild, sunny weather at optimal temperatures; conversely, bats remained inactive and silent during cold, cloudy conditions. Inactivity (resting) was more pronounced in winter (December–

January) than in autumn (October–November). Wing flapping occurred more frequently in autumn to dissipate body heat, whereas wing stretching was more prevalent in winter, as bats sought to absorb solar heat. Furthermore, wintering bats preferred upper branches to maximize sunlight exposure unlike in autumn when they occupied both the upper and upper-middle canopy.

g. Hanging and use of limbs

Bats suspend themselves using their claws. Observations indicated that the majority of bats (75%) hung solely by their feet—using either one or both—(Figure 1 e, f), while the remaining 25% employed various combinations of both feet and hands (Figure 1 g, h, i, j).

h. Sexes

Both adult males and females were present in the colonies (Figure 2 k, l), though no juveniles or pups were observed.

i. Ethogram

An ethogram of Indian Flying Fox behaviours recorded during the study period is shown in Table 4.

Table 4: Ethogram of Indian Flying Fox behaviours recorded during the study period

Category	Behaviour	Description	Average Duration
Inactive	Resting	The bat remains motionless and silent, hanging pendant with eyes either partially or fully closed. Wings are either partially (Figure 1 k) or fully wrapped around the torso (Figure 1 l).	Variable (minutes to hours)
Active Body Movements	Posture Changes	The bat adjusts its roosting position using its limb claws. This involves rotational movement from a vertical (head-down) to a horizontal (head and body raised), or lateral position (Figure 1 m, n, o, p).	30–40 seconds
	Grooming	The bat scratches or licks its body—specifically the ventrum, head and genital regions—using the tongue, mouth and claws (Figure 2 a, b).	30–60 seconds
Wing Movements	Wing Flapping	The bat beats one or both wings rapidly and repeatedly (Figure 2 c).	25–40 seconds
	Wing Stretching	The bat extends its wings horizontally on one or both sides of the body (Figure 2 d).	40–150 seconds
Locomotion	Branch Crawling	The bat traverses branches using all four limbs, gripping with claws on one side then to the other to move forward. (Figure 2 e).	20–35 seconds
	Flight (Long)	The bat engages in sustained circular flight, either returning to the same / different branch or shifting to a different tree (Figure 2 f). There is a higher likelihood of bats moving to a new tree than returning to their original spot.	35–70 seconds
	Flight (Short)	Brief, linear flights between branches of the same tree or to an adjacent tree.	2–5 seconds
Social	Agonistic (Fighting)	Physical quarrel between two bats in close proximity involving striking with their mouths or claws and utterance of high-pitched vocalisations to displace the opponent (Figure 2 g).	15–20 seconds
	Vocalisation	Chattering, squawking or squeaking calls (e.g.,... <i>chreee...kree...kwah...</i>). The frequency and pitch of calls increases during activities like fighting and courtship.	20–40 seconds
Mating	Courtship	The male approaches the female, often licking her genitals or torso, while the female may attempt to evade with high-pitched calls (Figure 2 h).	35–50 seconds

Excretion	Elimination	The bat inverts its position (head upward, excretory organs downward) to defecate or urinate (Figure 2 i). Excreta or stains of excretory wastes are often visible on the vegetation below roosting trees (Figure 2 j).	2–4 seconds
-----------	-------------	---	-------------

Threats

a. Disturbances

At the Jassur site, disturbances included the construction of the National Disaster Response Force (NDRF) office boundary wall and buildings adjacent to roosting trees. NDRF workers were observed using firecrackers and smoke to forcibly displace the bats. Several bird species—including little cormorants, little egrets, cattle egrets, house crows, large-billed crows and black kites—were documented resting near or flying over the roosting sites. Specifically, groups of 5–15 little cormorants were observed roosting near bats during the evening (Figure 2 m). Furthermore, small groups of house and large-billed crows (2–6 individuals) harassed the bats with loud, repetitive calls. Similarly, at the Kotla site, large-billed crows (2–4) and black kites (2–10) frequently overflowed the colonies in the evening, with the crows vocalising aggressively toward the bats.

b. Accidental Injuries

At the study sites, some bats were observed having one or more holes in their wings due to wing perforations (Figure 2 n). These injuries likely resulted from physical trauma caused

by sharp objects such as thorns or plant shoots, predator attacks and interaction with man-made structures.

c. Electrocutation

During the study, several bat carcasses were found suspended from overhead electricity wires in the vicinity of roosting sites. The Jassur site, located 200 m from an 11 kV power feeder station, is surrounded by both high-voltage and domestic supply lines. Two electrocuted bats were recovered from agricultural fields near Lakhnat village (32.383373° N, 75.912377° E; 650 m), situated 10 km from Jassur (Figure 2 o). Similarly, the Kotla roosting site is surrounded by domestic supply wires; another electrocuted bat was identified on roadside wires in Solda village (32.245917° N, 76.057597° E; 610 m), 2 km from Kotla.

d. Habitat Destruction

Significant habitat destruction was observed at the Jassur site, driven by a four-lane highway expansion involving land excavation and the removal of large, ancient roadside trees. Conversely, the habitat impact at the Kotla site was minor, limited primarily to the trimming of branches by local residents.



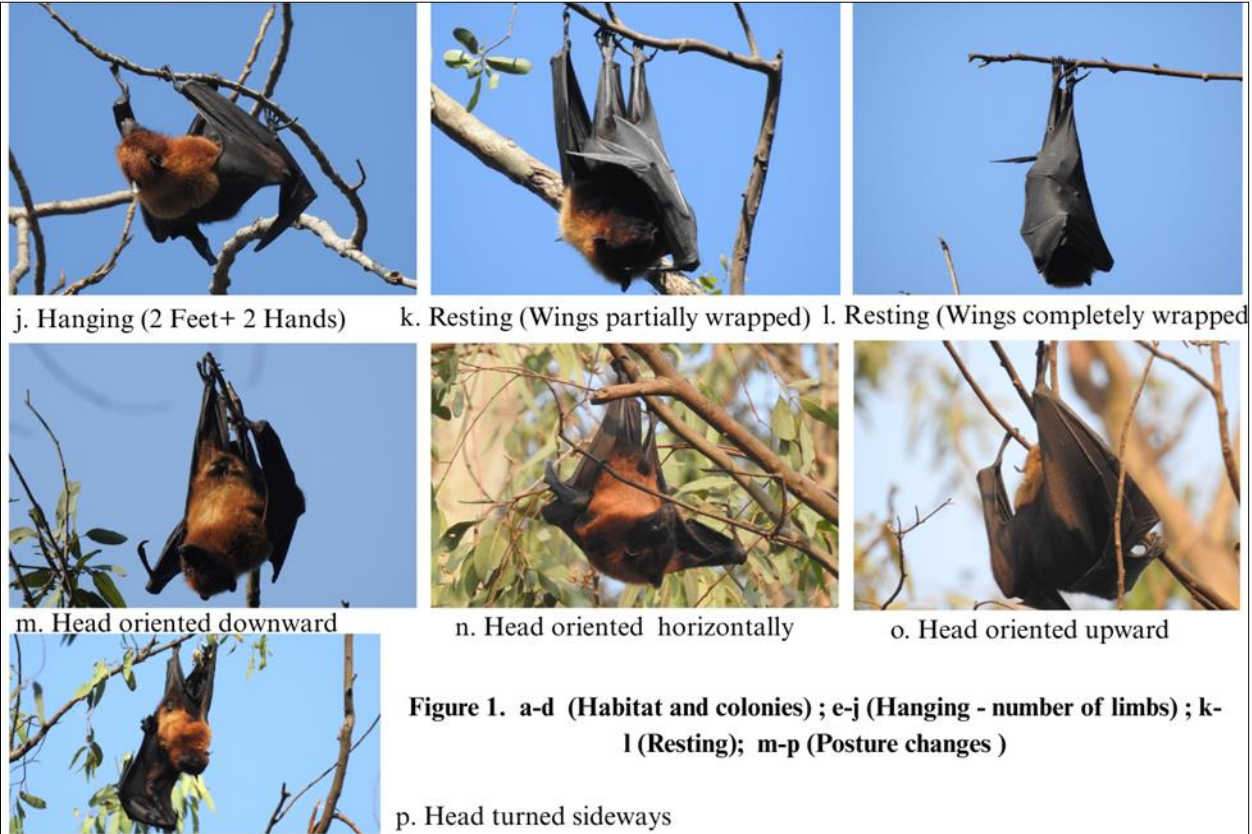


Figure 1. a-d (Habitat and colonies) ; e-j (Hanging - number of limbs) ; k-l (Resting); m-p (Posture changes)



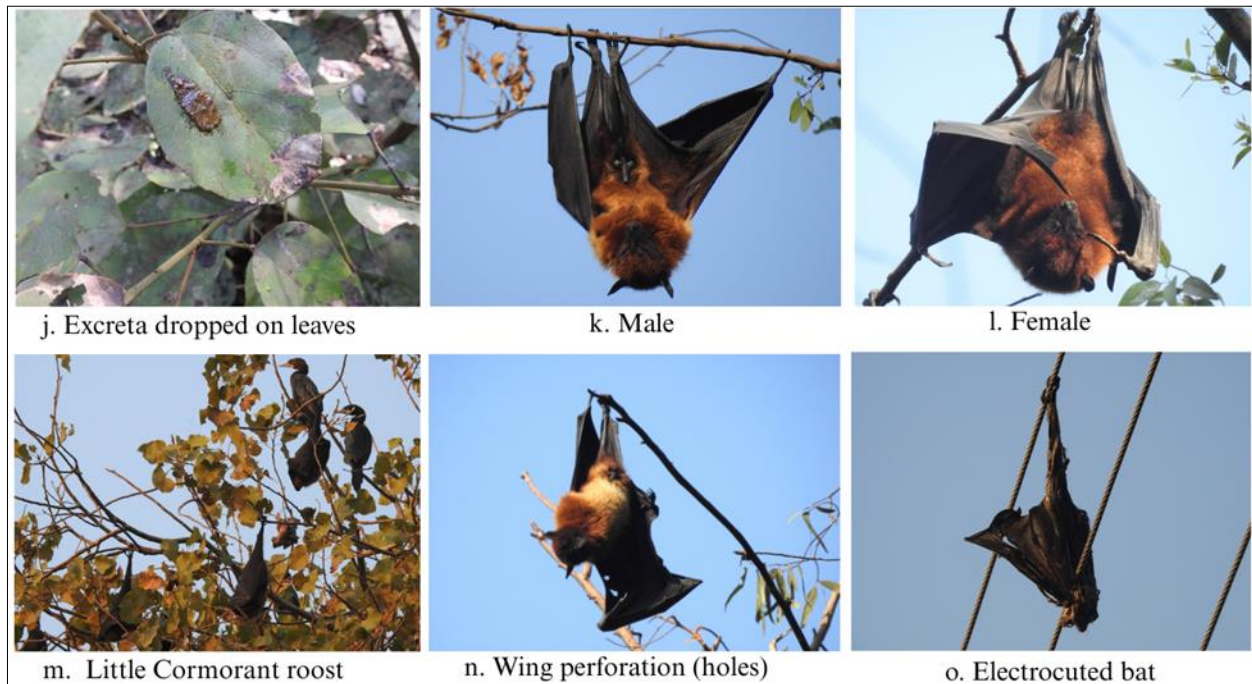


Figure 2: a-b (Grooming); c (Wing Flapping); d (Wing Stretching); e (Crawling); f (Flight); g (Fighting); h (Courtship); i (Defecating); j (Excreta); k (Male); l (Female); m (Little Cormorant roost); n (Wing perforation); o (Electrocuted bat)

Discussions

Total bat population was higher in autumn (470 in October 2025) compared to winter (390 in January 2026). These seasonal fluctuations align with previous studies; for instance, Manandhar *et al.* (2017)^[14] recorded a minimum of 264 individuals in January and a maximum of 1,550 in October, Kathmandu Valley, Nepal. Similarly, Mishra *et al.* (2019)^[16] observed the largest colonies during the spring-summer months (1660 in May 2014) and decreased colony sizes in winter during a study in Delhi, India.

Bat colonies were observed on tall, large-statured trees at both study sites, specifically on *Eucalyptus tereticornis* and Poplar *Populus deltoides*. These findings align with previous research highlighting a preference for large-statured trees, including: 9 species of avenue trees in Delhi (Mishra *et al.* 2010)^[16]; 13 species in the northern districts of Tamil Nadu (Pandian and Suresh 2021)^[17]; 11 species in the Kasur district of Pakistan, where *Eucalyptus* sp. was the most frequently used (Masood *et al.* 2024)^[15]; and 6 species in the Sallaghari Forest of Nepal, where *Eucalyptus* sp. was the most abundant roost tree and *Populus* sp. supported the highest relative abundance of bats (Hyongaju *et al.* 2024)^[7].

Resting was the most frequent diurnal behaviour followed by body movements, wing movements, locomotion, vocalisation and fighting. This distribution aligns with Roy *et al.* (2020)^[21], who reported sleeping as the dominant behaviour followed by thermoregulatory, locomotive and communicative actions. Similarly, Connell *et al.* (2006)^[3] observed that 83% of bats slept during the day, with 17% engaged in other behaviours.

Analysis of diurnal behaviour showed that bats exhibited their lowest activity levels in the early morning (80% resting) (Table 3). In contrast, peak activity occurred in the late morning (45% active), followed by late afternoon (40% active) and early afternoon (35% active) (Table 3). This supports findings by Devi and Kumar (2024)^[4], indicating

that bats are primarily inactive or sleeping during early morning hours.

The frequency of bats resting (inactive) was higher in winter than in autumn. While wing flapping was more frequent during autumn, wing stretching was more prevalent in winter. These findings align with Roy *et al.* (2024)^[21], who observed a higher incidence of sleeping behaviour in winter than in summer, alongside increased thermoregulatory, locomotive and communicative behaviours during the summer. Similarly, Devi and Kumar (2024)^[4] noted that sleeping and wing spreading were more common in winter, whereas wing flapping peaked in summer.

The majority of observed bats (75%) hung from tree branches using their feet (either one or both feet), while the remaining (25%) utilized various combinations of hands and feet (Figure 2 a–f). In comparison, Rao and Poyyamoli (2017)^[20] noted that most bats use both legs for hanging; whereas, Pandian and Suresh (2021)^[17] observed that 88.7% of bats use both legs and 11.3% use a single leg.

At both Kotla and Jassur sites, the number of bats across 23 roosting trees (*Eucalyptus tereticornis* and *Populus deltoides*) varied significantly. On average, the population per tree ranged from 6 to 52 individuals (Table 2). In comparison to other studies, Gulraiz *et al.* (2015)^[6] recorded a range of 8 bats (on *Manilkara* sp., 14.4 m height) to 88 bats (on *Pinus* sp., 13.4 m height).

Out of 23 roosting trees, Kotla colonies exclusively utilized *Eucalyptus tereticornis* (n=11; mean height: 27.9 m, range: 25–30 m; mean DBH: 35.3 cm, range: 22–42 cm). Conversely, Jassur colonies occupied both *Eucalyptus tereticornis* (n=6; mean height: 31 m, range: 28–35 m; mean DBH: 61.1 cm, range: 52–71 cm) and *Populus deltoides* (n=6; mean height: 23.8 m, range: 20–26 m; mean DBH: 44.6 cm, range: 42–47 cm). A positive correlation was found between bat counts and tree height as well as with diameter at breast height (DBH). In comparison to other studies, Gulraiz *et al.* (2015)^[6] observed that among 50 roosting trees from 23 species, tree height varied from 7.5 m

(*Dendrocalamus* sp.) to 19.8 m (*Celtis* sp.), while DBH ranged from 10 cm (*Putranjiva* sp.) to 89 cm (*Kigelia* sp.). Similarly, Masood *et al.* (2024) ^[15] recorded 103 roosting trees across 11 species, with heights ranging from 15 m (*Azadirachta* sp.) to 25 m (*Eucalyptus* sp.) and DBH values varying from 114 cm (*Ficus* sp.) to 120 cm (*Delonix* sp.). Diurnal active behaviours were observed for a minimum of 5 minutes or until the specific activity concluded. The average duration of these behaviours—including grooming, posture changes, flapping, stretching, crawling, flight, vocalisation, fighting, courtship and elimination—varied from 2 to 150 seconds (Table 4). The shortest durations (2-5 seconds) were recorded for short flights and excretion, while longest durations (40-150 seconds) were observed for wing stretching, long flights and grooming (Table 4). Resting periods varied from minutes to hours. In contrast to other studies that used 2-minute observation sessions (Manadhar *et al.* 2017; Devi and Kumar 2024) ^[14, 4], this study allowed for longer, more detailed observations.

Threats to bat survival include habitat destruction caused by construction and highway expansion, as well as disturbances from humans attempting to forcibly remove them. Additionally, the presence of birds—such as cormorants, egrets, crows and kites—roosting or flying near bat colonies, along with electrocution from parallel high-voltage wires and accidental wing injuries, poses significant risks. These findings align with other studies: Prajapati *et al.* (2019) ^[19] identified electrocution, human persecution and habitat alteration as primary threats; Pandian and Suresh (2021) ^[4] noted that smoke from shrines and the proximity of predatory birds (crows and kites) disturb roosting populations; Kumar *et al.* (2021) ^[10] emphasized habitat destruction, roost disturbance, electrocution and hunting as the main factors endangering bat sites.

Conclusion

The bat populations at both sites (Kotla and Jassur) fluctuated from a maximum of 240 individuals in Jassur during autumn to a minimum of 190 individuals in Kotla during winter. Roosting tree heights (H) varied from 20–26 m for Poplar to 25–35 m for Eucalyptus, while the diameter at breast height (DBH) ranged from 42–47 cm and 22–71 cm, respectively. A higher percentage of bats were inactive (resting) during the early morning. Activity peaked during the late morning, followed by the late and early afternoon. Throughout the observation periods, resting was the most prevalent behaviour, followed by body movements, wing movements, locomotion, vocalisation, and fighting. The average duration of these active behaviours varied from 2 to 150 seconds. Bats were significantly less active during winter than in autumn, and their activity levels dropped further during adverse weather conditions compared to normal conditions. The primary threats to bat survival included habitat destruction, disturbances, electrocution and accidental injuries.

References

1. Anjum Km N, Kumar V, Ali M, Elangovan V. Seasonal Influence on the Diurnal Behaviours of the Indian Flying Fox (*Pteropus medius*) in Lucknow, India. *Uttar Pradesh Journal of Zoology*, 2024;45(17):546-556. <https://doi.org/10.56557/upjz/2024/v45i174399>
2. Chakravarthy AK, Yeshwanth HM. Status of Roost of Indian Flying Fox (*Pteropus giganteus* Brunnich) in Karnataka, South India. *Bat Net-CCINSA Newsletter*, 2008;9:16-18.
3. Connell KA, Munro U, Torpy FR. Daytime behaviour of the grey-headed flying fox *Pteropus poliocephalus* Temminck (Pteropodidae-Megachiroptera) at an autumn/winter roost. *Australian Mammal*, 2006;28(1):7-14. DOI:10.1071/AM06002
4. Devi R, Kumar P. Diurnal Roosting Behaviour of Indian Flying Fox *P. medius* Temminck, 1825 (Mammalia: Chiroptera: Pteropodidae) in Kurukshetra District, Haryana. *Proceedings of Zoological Society*, 2024;77:511-524. <https://doi.org/10.1007/s12595-024-00552-2>
5. Ferrar ML. Daily flighting of flying foxes (*Pteropus giganteus* Brunn.) *Journal of the Bombay Natural History Society*, 1934;37:214-215.
6. Gulraiz TL, Javid A, Mahmood-UI-Hassan M, Maqbool A, Ashraf S, Hussain M, Daud S. Roost characteristics and habitat preferences of Indian flying fox (*Pteropus giganteus*) in urban areas of Lahore, Pakistan. *Turkish Journal of Zoology*, 2015;39(3):388-394. <https://doi.org/10.3906/zoo-1401-71>
7. Hyongaju S, Subba A, Maharjan M, Khanal L. Roost characteristics of Indian flying fox along urban noise gradient: A case study in Sallaghari Forest, Kathmandu Valley, Nepal. *Ecocycles*, 2024;10(1):105-114. <https://doi.org/10.19040/ecocycles.v10i1.439>
8. Koju NP, Chalise MK. Diurnal observation of population and general behavior of flying fox (*Pteropus giganteus*) in Sallaghari, Bhaktapur, Nepal. *Journal of Natural History Museum*, 2010;25:256-265.
9. Kumar R, Elangovan V. Effect of tree characteristics on roost selection of the Indian flying fox *Pteropus giganteus*. *Journal of Bat Research and Conservation*, 2019;12(1):100-106. <https://doi.org/10.14709/Barbj.12.1.2019.13>
10. Kumar J, Kanaujia A, Verma R. Various threats to survival of bats in district Lakhimpur-Kheri, Uttar Pradesh, India. *Asian Journal of Conservation Biology*, 2021;10(2):337-342.
11. Kumar R, Prasad DN, Elangovan V. An Update on Distribution of the Indian Flying Fox, *Pteropus giganteus* in Uttar Pradesh, India. *Trends in Biosciences*, 2017;10(37):7794-7801.
12. Kunz TH. Roosting Ecology of Bats. In: Kunz TH, editor. *Ecology of Bats*. Boston, MA: Springer, 1982, 1-55. https://doi.org/10.1007/978-1-4613-3421-7_1
13. Lindsay HM. Report No 44: Kangra and Chamba, Bombay Natural History Society's Mammal Survey of India. *Journal of the Bombay Natural History Society*, 1927;31:597-607.
14. Manandhar S, Thapa S, Shretha TK, Jyakhwo R, Wright W, Aryal A. Population Status and Diurnal Behaviour of the Indian Flying Fox *Pteropus giganteus* (Brunnich, 1782) in Kathmandu Valley, Nepal. *Proceedings of the Zoological Society*, 2017;71(4):363-375. <https://doi.org/10.1007/s12595-017-0219-x>
15. Masood M, *et al.* Distribution and roosting preferences of Indian flying fox (*Pteropus medius*) in District Kasur, Punjab, Pakistan. *Journal of Wildlife and Biodiversity*, 2024;8(4):173-183. <https://doi.org/10.5281/zenodo.13835162>
16. Mishra R, Dookia S, Bhattacharya P. Avenue Plantations as Biodiversity Havens: A Case Study of Population

- Status of the Indian Flying Fox, *Pteropus giganteus* Brunnich, 1782 and Implications for Its Conservation in the Urban Megacity, Delhi, India. Proceedings of the Zoological Society, 2019:73:127-136. <https://doi.org/10.1007/s12595-019-00308-3>
17. Pandian M, Suresh S. Roosting habits and habitats of Indian Flying Fox *Pteropus medius* Temminck, 1825 in the northern districts of Tamil Nadu, India. Journal of Threatened Taxa, 2021:13(12):19675-19688. <https://doi.org/10.11609/jott.7468.13.1219675-19688>
 18. Paul SK, Paul R, Mitter H, Singh L, Chandel GS. Bats and People: Harmony with Conflict. ZOO'S PRINT Small Mammal Mail- Newsletter of CCINSA & RISCINSA, 2009:1(1):10.
 19. Prajapati J, Chalise MK, Karmacharya DK. Habitat and Behavioural Observation of Indian Flying Fox *Pteropus giganteus* (Brunnich, 1782) in Sallaghari, Bhaktapur, Nepal. Journal of Natural History Museum, 2020:31(1):79-94. <https://doi.org/10.3126/jnhm.v31i1.39376>
 20. Rao S, Poyyamoli G. Roosting, Foraging and Mating Behaviour of Indian Flying Fox (*Pteropus giganteus*) in Rourkela, Odisha. July 22, 2017. Available at SSRN: <https://doi.org/10.2139/ssrn.3007088>
 21. Roy K, Saha GK, Mazumdar S. Seasonal influence on the diurnal roosting behaviour of free-ranging Indian flying fox *Pteropus giganteus* in an urban landscape, India. Biologia, 2020:75:1955-1961. <https://doi.org/10.2478/s11756-020-00472-4>
 22. Saikia U, Thakur ML, Bawri M, Bhattacharjee PC. An inventory of the chiropteran fauna of Himachal Pradesh, northwestern India with some ecological observations. Journal of Threatened Taxa, 2011:3(4):1637-1655. <https://doi.org/10.11609/JoTT.o2409.1637-55>
 23. Vyas R, Upadhyay K. Study of the Indian Flying Fox (*Pteropus giganteus*) Colonies of Jambughoda Wildlife Sanctuary, Gujarat, India: Record of largest roosting congregation at Targol. Small Mammal Mail-Newsletter of CCINSA & RISCINSA, 2014: 6(1):1-7.