Uttar Pradesh Journal of Zoology

Volume 45, Issue 16, Page 427-437, 2024; Article no.UPJOZ.3869
ISSN: 0256-971X (P)

Distribution and Habitat Selection of Indian Flying Fox, *Pteropus medius* (Temminck, 1825) in Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i164325

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3869

Original Research Article

Received: 27/05/2024
Accepted: 31/07/2024
Published: 05/08/2024

ABSTRACT

The present study examines the distribution and habitat selection of Indian flying fox, *Pteropus medius* in Uttar Pradesh, India. A through field work conducted across six districts revealed 22 roosting locations with a total population of approximately 12,023 bats. These sites were located at rural (12), semi-urban (2), urban (1), agricultural (5), and industrial (2) areas, and a majority of roost sites observed close to human habitations. *Pteropus medius* preferred to roost on 20 species of trees which indicate wide-ranging habitat preferences. Although there were considerable differences in tree attributes across different species, such as tree height (ranging from 9.54 to

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Cite as: *Anjum, Km Naheda, Debopriya Saha, Pooja Tiwari, Manjulendra Kumar, and Vadamalai Elangovan. 2024. "Distribution and Habitat Selection of Indian Flying Fox, Pteropus Medius (Temminck, 1825) in Uttar Pradesh, India". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (16):427-37. https://doi.org/10.56557/upjoz/2024/v45i164325.*

26.03 meters), canopy width (varying from 8.59 to 25.09 meters), crown height (ranging from 1.19 to 18.90 meters), circumference (ranging from 0.54 to 3.65 meters), and DBH (ranging from 0.17 to 3.73 meters), and there was no notable variation in bat occupancy per roost tree. The results of the regression analysis emphasized the significance of canopy width as a predictor of colony size, indicating its importance in identifying suitable roosting habitats for *P. medius*. ANOVA analysis indicated differences in tree characteristics across species, highlighting the necessity for through habitat evaluations. Subsequent post-hoc examination clarified distinct clusters of tree species with significant variations in roosting site features. These results underscore the intricate relationship between tree attributes and bat populations, emphasizing the significance of well-informed conservation approaches for the sustainable preservation of *P. medius* and the overall ecosystem well-being.

Keywords: Colony size; conservation; Indian flying fox; Pteropus medius; roost tree; Uttar Pradesh.

1. INTRODUCTION

Bats play a significant role in mammalian diversity globally, with an estimated 21 families, 213 genera and 1469 species under the order Chiroptera [1]. Their distribution covers most regions of the world, with exceptions being the Arctic, Antarctica, extreme desert areas and isolated oceanic islands. Notably, bats are the only mammals capable of powered flight [2]. Within the order Chiroptera, two suborders are present: Yinpterochiroptera (including Pteropodidae and Rhinolophoidae) and Yangochiroptera (rest of Microchiroptera) [1]. Three widespread fruit bat species found in India are *Pteropus medius*, *Rousetus leschenaulti*, and *Cynopterus sphinx* [3].

The Indian flying fox, *Pteropus medius* (Temminck, 1825), is one of the largest fruit bats globally and is widely distributed in India, especially in South Asia [4]. *Pteropus medius* demonstrates social behaviour by forming large groups consisting of hundreds to thousands of individuals. These groups can be found roosting in tall trees various landscapes such as rural and urban areas near ponds, agricultural fields, and roads, with colony size ranging from a few hundred to several thousand individuals [4-6]. The Indian Flying foxes play a vital role in maintaining the ecosystem by aiding in pollination, dispersing seeds, and cycling nutrients, and they hold considerable economic value, providing support to over 114 plant species globally [7]. Despite being listed as 'Least Concern' on the IUCN Red List and receiving protection under Indian law, their numbers are decreasing due to factors such as habitat loss, deforestation, electrocution, food shortages, highway expansion, urbanization, disturbances caused by human activities, and hunting [8-11]. Despite these challenges, their essential ecological roles as seed dispersers, pollinators and forest regeneration, are often not fully appreciated [12]. In Uttar Pradesh, the ability of *Pteropus medius* to survive and reproduce, like other animals, depends on securing enough food and shelter, with daytime roosting locations being highly important. These roost sites are vital for *P. medius* activities such as mating, caring for offspring, socializing, and seeking protection from the weather and predators [13]. However, there is a lack of detailed research on the habitat preferences and roosting needs of *P. medius* in Uttar Pradesh. This study, therefore, seeks to address this gap by identifying roosting colonies and documenting roost tree characteristics in selected districts of the state. Considering the wide distribution of *P. medius* in Uttar Pradesh across various habitats, factors such as habitat availability, tree traits, and proximity to human settlements are likely to impact population size and distribution. It is also hypothesized that human-induced pressures on habitat and uncertainties about the geographic range could pose a threat to the conservation status of *P. medius* in the region.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in six districts: Azamgarh, Barabanki, Shahjahanpur, Sitapur, Lakhimpur-Kheri, and Lucknow in Uttar Pradesh, India. The coordinates of all districts are provided in Table 2, and an exclusive cartogram was constructed with the help of Arc GIS software (Fig. 1). Agriculture in these districts relies heavily on tube wells and canals. Azamgarh is primarily agrarian, cultivating rice, wheat, pulses, and fruits like mangoes and guavas. Sitapur boasts agricultural diversity with wheat, rice,

sugarcane, and dairy farming prominent. Lucknow, although urban, engages in wheat, rice, and mango cultivation. Lakhimpur-Kheri is renowned for sugarcane, wheat, and dairy farming. Shahjahanpur focuses on wheat, rice, and sugarcane, while Barabanki's agriculture includes wheat, rice, and mangoes. These districts significantly contribute to Uttar Pradesh's agricultural output, showcasing the state's agricultural prowess. Across Azamgarh, Sitapur, Lucknow, Lakhimpur-Kheri, Shahjahanpur, and Barabanki, mangoes and guavas are major fruits cultivated abundantly. Additionally, bananas are significant in Azamgarh, while Sitapur adds citrus fruits like oranges and lemons to its repertoire. Lucknow, Lakhimpur-Kheri, Shahjahanpur, and Barabanki primarily focus on mangoes and guavas. These fruits not only contribute to the agricultural diversity of the region but also play a pivotal role in the horticultural economy, providing livelihoods and sustenance to the local communities while showcasing the rich agricultural heritage of Uttar Pradesh. The districts of Azamgarh, Sitapur, Lucknow, Lakhimpur-Kheri, Shahjahanpur, and Barabanki in Uttar Pradesh share a subtropical climate characterized by hot summers and cool winters. Summer temperatures range from 25°C to 45°C (77°F to 113°F), while winter temperatures hover between 5°C to 25°C (41°F to 77°F). The primary rainy season is during the monsoon months, from June to September. Despite slight variations, these districts generally experience analogous climatic conditions owing to their geographical proximity within Uttar Pradesh.

2.2 Data Collection

A survey was conducted in six districts of Uttar Pradesh, India, from January 2021 to March 2021 with the objective of identifying *P. medius* roosting sites. Information regarding the roosts was initially gathered through direct interactions and verbal inquiries with local peoples residing in proximity to the roost sites. The roosting locations of *P. medius* were determined using the direct roost count methodology [14]. The bats at each roosting site were observed and counted using Binoculars (Aculon A211, Nikon), and the sites were documented using a DSLR camera (Z7, Nikon). Simultaneously, the geo-coordinates of each roosting site were logged using a handheld Garmin device (Montana 680, Garmin) (refer Table 2). Additionally, the research was conducted to analyze the correlation between the population of bats per tree and specific tree characteristics across a variety of tree species. A total of 57 trees from different species, such as *Azadirachta indica, Mangifera indica, Eucalyptus* etc. were included in the data collection. The recorded parameters for each tree encompassed the bat population, roost tree height, canopy width, crown height of roost tree, circumference of roost tree, diameter at breast height (DBH), and trunk height (refer to Table 1 and Table 3). The field survey categorized each roosting site into agronomic, rural, urban, semi-urban, or industrial areas using direct observations and local knowledge, adhering to the criteria set by the Census of India (2011). Information on the number of trees utilized by bats at each roost, roost type, proximity of roosting sites to water bodies, agricultural fields, or roads, and the status of the roost was also collected. This classification method, which is based on the researchers' expertise and firsthand experience in the study area, provides valuable insights into the various habitats utilized by *P. medius.*

2.3 Analysis

This investigation carried out a systematic investigation to examine the relationship between different attributes of trees (e.g., species, height, canopy width, crown height, diameter at breast height (DBH), and trunk height) and an unmentioned dependent variable termed as colony size. The sample consisted of 20 locations, and an exhaustive review of the data was performed to ensure its integrity, uniformity, and identification of any anomalies. Descriptive metrics such as mean and standard deviation, were computed for each parameter. Levene's test was applied to examine the equality of variances. We performed one- way ANOVA tests to analyze the variations in tree features across various tree species. Subsequently, Tukey's Honestly Significant Difference (HSD) post-hoc assessments were utilized for pairwise comparisons between the tree species. The variables were standardized or normalized to enable meaningful comparisons. Following this, we developed a multiple linear Regression model with colony size as the outcome variable and tree characteristics as independent variables. The model was fitted to the data using statistical software, and coefficients were estimated through the least squares regression method. We evaluated the model's effectiveness by analyzing indicators such as the multiple correlation coefficients (Multiple R), coefficient of determination (R^2), and

adjusted R^2 to assess general suitability. Additionally, we employed ANOVA to examine the regression model's statistical importance by contrasting explained and unexplained variability. Our analysis also entailed scrutinizing the coefficients table to comprehend the specific influence of each variable on the dependent variable, while considering significance levels and confidence intervals.

3. RESULTS

3.1 Roost Site Characteristics

During the research conducted in six districts of Uttar Pradesh, 22 roosting locations of *P. medius* were discovered, estimating a total population of around 12,023. Details regarding the coordinates, proximity to water bodies, human settlements, roads, and characteristics of the roost sites are presented in Table 1. Eight roosting sites were located within a 100-meter radius of water bodies, situated in Sitapur (four sites), Lakhimpur-Kheri (three sites), and Barabanki (one site). The research encompassed 12 rural areas, two semi-urban areas, one urban area, five agricultural areas, and two industrial areas, as specified in Table 2. In the study area, *P. medius* used both single (individuals aggregated on a single tree) and dispersed roosts (individuals aggregated on different trees at a roosting site). Deogao was identified as a single roost on a tall *Ficus religiosa* tree, accommodating 359 individuals of the Indian flying fox, while the other 21 roosts were dispersed. Among the identified roosts, 83.21% (n=10,005) of Indian flying foxes were found within a 100-meter radius of human settlements. The highest number of individuals, 36.58% (n=4,399), was in Shahjahanpur district, spread across 63 roosting trees in the six districts, while the lowest number, 1.03% (n=124), was in Lucknow district, across eight roosting trees.

3.2 Roost Tree Characteristics

A diverse range of tree species was found to serve as roosting sites for *P. medius*, totaling 183 trees belonging to 20 species from 17 genera and 11 families identified in the present study. The roost tree species in the study area included Mango (*Mangifera indica*), Crape Jasmine (*Tabernaemontana coronaria*), Date Palm (*Phoenix dactylifera*), Royal Poinciana (*Delonix regia*), Ashok (*Saraca asoca*), Indian Rosewood

Table 1. The tree characteristics were assessed by following the methods outlined in the American Forests Champion Trees Measuring Guidelines Handbook [15]

Parameter	Measurement Method
Tree Height (TH)	Hold a ruler or yardstick vertically at arm's length. Move forward or backward from the tree until the part of the stick from the top of hand to the top of the stick just covers the tree. Measure the length of the stick above hand to get the side 'b' of the small triangle abc. Measure the distance from eye to the top of hand (a). Measure the distance from eye past the top of hand and on to the base of the tree (A). Compute TH using the formula: TH = A / (a * b).
Trunk Height (TrH)	Similar to Tree Height measurement method. However, the stick is positioned to cover only the tree trunk. Measure the length of the stick above hand to get side 'b'. Measure the distance from eye to the top of hand (a). Measure the distance from eye past the top of hand and on to the base of the tree (A). Compute TrH using the formula: TrH = A / (a * b).
Canopy Height (CH)	Calculated by dividing trunk height (TH) by tree height.
DBH of Roost Tree	Measure the diameter at breast height (DBH) approximately 4.5 feet above tree base. Obtain DBH by dividing the circumference of the tree by 3.141.
Canopy Spread (CS)	Average of the widest span and the width of the crown at 90 degrees off.
Tree Canopy Width (CW)	View the tree from all sides to determine the side where the canopy is widest. Erect two range poles to mark the extreme edges of the canopy. Measure the distance between the two poles with a measuring tape and record as the canopy width [16].

Table 2. Roosting site characteristics and locations of *Pteropus medius* in Uttar Pradesh, India

Districts	Location	Colonysize	Latitude N	LongitudeE	Distancefrom Roost to Adjacent Road (m)	Distance from Roost to Human Residence(m)	Distance from Roost Area to Water Body (m)
	Basulia	201	27°54'04"	79°57'13"	100.0	500.0	549.9
	Kanth	1362	27°43'20"	79°46'29"	100.0	50.0	200.0
	Azizganj	498	27°52'23"	79°53'30"	19.9	100.0	150.0
	Powayan	72	28°07'01"	80°05'45"	50.0	29.9	500.0
	Jalalpur	75	27°47'30"	79°56'02"	49.9	2000.0	1000.0
Shahjahanpur	Niwari	1120	27°57'03"	79°52'21"	69.9	99.9	500.0
	Barnava	113	27°46'41"	79°49'11"	29.9	400.0	700.0
	Goojarpur	958	27°44'31"	79°36'56"	49.9	199.9	400.0
	Hargaon	317	27°44'49"	80°48'22"	121.9	160.0	91.4
	lalbagh	1426	27°34'02"	80°40'48"	49.9	29.9	1000.0
	Husainganj	564	27°33'04"	80°42'30"	29.9	9.7	49.9
	Bishun nagar	123	27°31'17"	80°47'06"	9.9	29.9	799.9
	Mahadev purwa	992	27°27'59"	80°47'51"	19.9	9.9	500.0
	Niyajpur	543	27°44’55"	80°32'44"	21.3	46.	34.1
Sitapur	Dadabad	268	27°36'14"	80°31'59"	29.2	33.8	42.9
Azamgarh	Deogao	359	25°44'52"	82°59'12"	424.8	19.9	44.9
	Jhinguripurwa	164	27°52'44"	80°10'27"	39.9	29.9	99.9
	Mustafabad	230	27°50'32"	80°07'50"	250.0	360.9	900.0
Lakhimpurkheri	Murasa	390	27°78'75"	80.5593"	131.6	15.2	65.5
	Nimcheni	179	27°81'00"	80.53’31"	55.5	43.4	23.4
Lucknow	MeerakhNagar	124	26°35'23"	81°04'02"	99.99	2000	900
Barabanki	Bhagwanpur	1945	26°49'25"	81°15'03"	9.99	99.99	9.99

Table 3. Characteristics of roost trees utilized by *Pteropus medius* in Uttar Pradesh, India

Families	Roost Tree Species	No. of Roost Trees	No. of Bats Per Tree	% of Total Population	Tree Height(m)	Tree Crown Height(m)	Canopy Width (m)	Trunk Height (m)	DBH (m)
Anacardiaceae	*Mangifera indica*	**47**	61	**23.38**	16.26 ± 2.67	9.64 ± 2.88	20.06 ± 6.40	7.47 ± 5.86	0.68 ± 0.25
Apocynaceae	*Tabernaemontana coronaria*	5	34	1.36	9.54 ± 9.48	**1.89 ± 0.83**	8.59 ± 1.23	7.65 ± 10.04	0.95 ± 0.50
Arecaceae	*Phoenix dactylifera*	3	29	0.44	30.31 ± 0.00	11.31 ± 0.00	11.32 ± 0.00	19.01 ± 0.00	0.49 ± 0.00
Fabaceae	*Delonix regia*	3	70	1.72	10.59 ± 0.00	6.22 ± 0.00	18.38 ± 0.00	**4.38 ± 0.00**	0.39 ± 0.00
	Saraca asoca	2	82	1.35	13.22 ± 5.77	7.44 ± 2.84	12.01 ± 5.01	5.79 ± 2.93	0.39 ± 0.31
	Dalbergia sissoo	2	82	1.34	22.26 ± 1.49	15.39 ± 2.37	14.53 ± 2.45	6.88 ± 0.88	0.43 ± 0.23
Lamiaceae	*Tectona grandis*	19	104	5.33	26.03 ± 10.39	13.29 ± 2.99	14.39 ± 2.06	12.75 ± 7.58	0.41 ± 0.12
Meliaceae	*Azadiracta indica*	9	63	4.62	20.46 ± 6.04	10.87 ± 6.14	13.30 ± 5.83	9.59 ± 8.14	0.54 ± 0.22
	Melia azedarach	2	19	**0.30**	11.79 ± 0.00	6.63 ± 0.00	19.65 ± 0.00	5.17 ± 0.00	0.67 ± 0.00
Myrtaceae	*Eucalyptus*	31	43	10.82	24.37 ± 0.82	16.09 ± 0.63	12.84 ± 0.45	10.98 ± 6.88	**0.25 ± 0.05**
	Syzygium cumini	6	109	4.16	19.08 ± 1.07	10.76 ± 0.52	15.33 ± 1.40	8.33 ± 0.57	0.54 ± 0.00
Moraceae	*Ficus virens*	**1**	**197**	1.62	27.24 ± 0.00	10.89 ± 0.00	**34.74 ± 0.00**	16.37 ± 0.00	1.01 ± 0.00
	Ficus religiosa	7	170	9.75	19.99 ± 7.54	12.94 ± 4.20	17.69 ± 8.48	7.06 ± 5.60	1.08 ± 0.66
	Artocarpus lacucha	8	59	3.83	15.53 ± 1.94	7.42 ± 1.48	25.09 ± 6.16	8.12 ± 0.52	**2.87 ± 1.44**
	Ficus benghalensis	2	27	0.72	12.19 ± 0.00	10.66 ± 0.00	7.62 ± 0.00	1.52 ± 0.00	1.58 ± 0.00
	Ficus racemosa	9	57	16.11	21.33 ± 3.27	13.02 ± 1.43	15.33 ± 1.99	8.33 ± 2.30	0.62 ± 0.32
Rutaceae	*Limonia acidissimia*	**1**	59	0.48	**9.14 ± 0.00**	5.79 ± 0.00	17.31 ± 0.00	3.36 ± 0.00	0.83 ± 0.00
	Aegle marmelos	**1**	**11**	0.09	24.54 ± 0.00	2.05 ± 0.00	**6.09 ± 0.00**	**19.91 ± 0.00**	0.70 ± 0.00
Sapotaceae	*Madhuca longifolia*	5	74	0.61	19.05 ± 0.00	9.19 ± 0.00	27.21 ± 0.00	9.88 ± 0.00	2.47 ± 0.00
Ulmaceae	*Holoptelea integrifolia*	20	73	11.97	**33.60 ± 5.34**	**16.86 ± 1.31**	11.32 ± 0.32	16.75 ± 4.03	0.99 ± 1.12

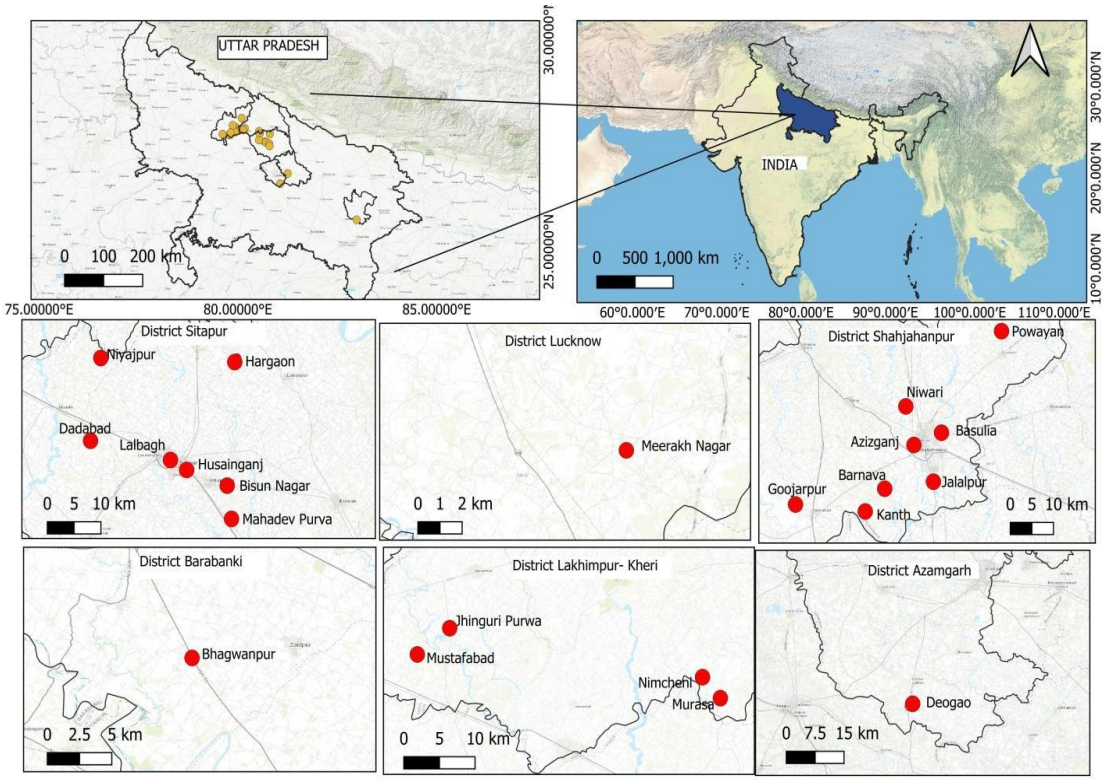

Fig. 1. Roosting sites of Indian flying fox, *Pteropus medius* in Uttar Pradesh

(*Dalbergia sissoo*), Teak (*Tectona grandis*), Neem (*Azadirachta indica*), Chinaberry (*Melia azedarach*), Eucalyptus (*Eucalyptus* sp.*),* Java Palm (*Syzygium cumini*), White fig (*Ficus virens*), Sacred fig (*Ficus religiosa*), Monkey fruit (*Artocarpus lacucha*), Banyan (*Ficus benghalensis*), Cluster Fig (*Ficus racemosa*), Wood apple (*Limonia acidissimia*), Bael (*Aegle marmelos*), Mahua (*Madhuca longifolia*), and Indian Elm (*Holoptelea integrifolia*). The roost sites ranged from one tree species (Deogao) to a maximum of seven tree species (Lalbagh).

3.3 Descriptive Statistics Analysis

The Descriptive statistics demonstrate a wide variety of tree attributes that were recorded in the study. The average number of bats per tree ranged from 29.67 to 167.80 for different tree species, showing varying levels of bat occupancy. The height of the trees displayed significant diversity, extending from 9.54 meters to 26.03 meters, indicating discrepancies in vertical roosting habitat availability. Similarly, the canopy width showed a wide range, fluctuating from 8.59 meters to 25.09 meters, signifying variations in the spatial extent covered by tree canopies. The crown height of trees where bats roosted ranged from 1.19 to 18.90 meters, demonstrating variations in the vertical dimension of roosting locations. The circumference of these trees varied from 0.54 to 3.65 meters, indicating differences in the size and thickness of the roosting trees. The diameter at breast height (DBH) showed variability from 0.17 to 3.73 meters suggesting disparities in the thickness of the tree trunks. The trunk height spanned from 1.22 to 24.90 meters, pointing out differences in the vertical length of the tree trunks. These findings underscore the diverse characteristics of the habitat in the study area and their potential impact on the roosting behavior and population dynamics of bats.

3.4 Regression Analysis

A regression analysis was performed to investigate the connection between tree traits and *P. medius* colony size. The results showed that the overall regression model was not statistically significant at the typical 0.05 significance level, though it came close. This suggests that while there may be some link between tree traits and colony size, there are likely other unaccounted-for factors influencing *P. medius* population dynamics. Of the tree traits studied, canopy width stood out as a statistically

significant indicator of colony size, indicating that the horizontal span of the canopy may be crucial in determining suitable roosting sites for *P. medius*. The canopy width of roost trees ranged from 6.09 ± 0.00 m for Bael (*Aegle marmelos*) to 34.74 ± 0.00 m for White fig (*Ficus virens*), with an average canopy width of 16.50 ± 6.64 m. The analysis revealed a significant positive correlation between bat abundance (colony size/tree) and roost tree characteristics like canopy width ($P < 0.047$), suggesting that the roost's canopy width influences roosting behavior of *Pteropus medius*. However, the lack of significance for other variables such as tree height, crown height, DBH, and trunk height indicates that these factors may not directly affect colony size, at least within the scope of this study.

3.5 One Way ANOVA Analysis

The ANOVA findings indicated notable disparities among different tree species in various essential tree attributes. Notably, significant disparities were noted in the height of roost tree ($F = 3.176$, $p = 0.003$), canopy width ($F = 2.646$, $p = 0.011$), crown height of roost tree ($F = 6.676$, $p < 0.001$), circumference of roost tree ($F = 4.553$, $p < 0.001$), and diameter at breast height (DBH) ($F = 4.553$, $p < 0.001$).These findings indicate that there are noticeable variations in certain characteristics among different tree species, which could impact their suitability as roosting sites for bats. However, the ANOVA results revealed non- significant differences in the bat population per tree ($F = 1.926$, $p = 0.061$) and trunk height ($F = 0.428$, $p = 0.935$) across various tree species. This implies that the density of bat population and trunk height may not be significantly affected by the specific tree species, thus emphasizing the importance of other factors in determining bat roosting preferences and habitat selection.

3.6 Post-hoc Analysis

A post-hoc analysis, using Tukey's honest significant difference (HSD) test, identified particular groupings of tree species that exhibited notable variations in the height of roost trees, canopy width, crown height of roost trees, roost tree circumference, and diameter at breast height (DBH).

4. DISCUSSION

The number of bats roosting on each tree ranged from 11 to 197. Most of the examined flying foxes from the *Pteropus* genus display a moderate to strong tendency to form colonies [17]. In India, relatively small colonies have been documented, with figures of 500 [18] and 800-1000 [19]. The largest observed colony in Bangladesh was home to 2500 bats [20]. Out of the total 23 roosting sites, seven hosted 500 or more bats. The site for roosting with the least abundance of bats, totaling 72, was identified in Powayan, Shahjahanpur. The low number of bats is attributed to the existence of deteriorating trees and disturbances caused by human activities. In contrast, the largest bat population (1945 bats) was recorded in Bhagwanpur, Barabanki. The average bat count per roosting site ranged from 400-550, indicating a gradual decline in colony size. Bats strongly select water bodies with bankside vegetation, tree line, and the edges of deciduous and mixed woodlands, while avoiding open areas such as upland/unimproved grassland and improved grassland [21]. *Pteropus medius*, given its broad distribution through various habitats in Uttar Pradesh, is impacted by factors such as habitat availability and tree characteristics near human settlements. Additionally, the response of bats to prey abundance in relation to habitat characteristics, as shown [22], is an important factor influencing their roosting and foraging behaviour.

4.1 Tree Species Selection for Roosting

The Indian flying fox, *P. medius* has been observed to utilize a range of tree species in different regions. Mishra [23] reported nine tree species in avenues in Delhi, Kumar et al. [24] identified 18 tree species in Uttar Pradesh, and Pandian and Suresh [25] documented 13 tree species in northern Tamil Nadu. In the current study conducted in Shahjahanpur, Sitapur, Lakhimpur-Khiri, Lucknow, and Barabanki districts in Uttar Pradesh, *P. medius* populations were found to use 20 species belonging to 17 genera and 11 families for roosting. Among these, *Mangifera indica* and *Eucalyptus* sp. were the most favored by the Indian flying fox in Uttar Pradesh. Similarly, in the Kathmandu region (Nepal), Manandhar et al. [26] found that different species of *Eucalyptus* (Myrtaceae) were the most used trees for roosting. In the current study, the *Eucalyptus* tree was the second most preferred by *P. medius* after *Mangifera indica*. On the other hand, Pandian and Suresh [25] reported that *T. indica* and *L. coromandelica* are the most preferred trees by the flying fox in Tamil Nadu, but these trees were not the top choices for *P. medius* in

the present study. These findings suggest that *P. medius* demonstrates variability in tree species utilization across different geographical regions, showing inconsistency in tree selection for roosting.

4.2 Apparent Preference of Trees Close to Human Dwellings

In the region of the Indian subcontinent, the majority of *P. medius* populations tend to select trees as their roosting sites near areas inhabited by humans [27]. In lower Nepal, the majority of *P. medius* colonies were observed in proximity to human settlements and agricultural lands [28]. This particular species is inclined to roost on trees located in close proximity to human settlements in the Tirunelveli district, encompassing sacred groves and agricultural areas [29]. The current investigation reveals that 78% of *P. medius* individuals (n=10727) were situated within a 100 m radius from human settlements [27-28].

5. CONCLUSION

The research examined the roosting behaviour and preferred habitats of *Pteropus medius,* also known as the Indian flying fox, in Uttar Pradesh, India. It discovered 22 roosting locations with an estimated population of about 12,023 individuals, primarily located near human communities. The study observed a variety of tree species used as roosting sites, with *Mangifera indica* and *Eucalyptus* sp. being the most favored. The roosting locations were spread throughout different types of environments, such as rural, semi-urban, urban, agricultural, and industrial areas. Both solitary and scattered roosting sites were identified, with most bats inhabiting areas within a 100 meter distance from human settlements. The trees used for roosting encompassed 20 distinct species, showcasing a varied range of habitat usage by *P. medius.* Although there were notable disparities in tree attributes across species, there were no significant differences in the number of bats per tree and trunk height. Through regression analysis, it was determined that the width of the canopy has a considerable impact on the size of bat colonies, demonstrating its significance in identifying suitable roosting locations for *P. medius.* The ANOVA results further emphasized variations in specific tree attributes among different species, underscoring the importance of comprehending these factors in habitat management and conservation endeavors. Subsequent analysis provided additional insights into distinct groupings of tree species with significant discrepancies in roosting site characteristics. Ultimately, these outcomes highlight the intricate connection between tree attributes and bat populations, underscoring the necessity of comprehensive habitat evaluations and conservation approaches tailored to the distinctive needs of *P. medius.*

6. RECOMMENDATIONS

To conserve *Pteropus medius* populations in Uttar Pradesh, a holistic approach is indispensable. First and foremost, it is crucial to conserve natural habitats that are home to significant bat populations by protecting forests, preserving green spaces, and minimizing deforestation and habitat degradation. Secondly, it is vital to address conflicts between humans and bats, especially near human settlements, through raising awareness, promoting sustainable land-use practices, and establishing buffer zones around roosting sites. Thirdly, it is imperative to integrate wildlife conservation considerations into urban planning by safeguarding roosting sites and migration corridors, and ensuring that infrastructure projects factor in the needs of bats and other wildlife species. Fourthly, it is vital to support ongoing research and monitoring efforts to enhance understanding of bat ecology, behaviour, and population dynamics for effective conservation measures. Moreover, it is necessary to strengthen legislation and enforcement mechanisms to protect bats and their habitat, including enacting regulations to address threats like deforestation, habitat destruction, and hunting, and ensuring their proper implementation. Lastly, community engagement plays a key role, so collaboration with local communities, conservation organizations, and stakeholders is essential to promote community-based conservation initiatives. Encouraging participation in habitat restoration, wildlife monitoring, and awareness campaigns can generate support for bat conservation efforts and ensure the long-term survival of *P. medius* populations in Uttar Pradesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENTS

The financial assistance of the Science and Engineering Research Board New Delhi through a core research grant (F. No. CRG/2019/000278) to VE is acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/3869