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Cover: Common Keeled Skink *Eutropis carinata* in oil pastels, colour pencils, & micron pen adapted from photograph by H. Byju © Pooja Ramdas Patil.



Distribution status and roost characteristics of Indian Flying Fox *Pteropus medius* Temminck, 1825 (Mammalia: Chiroptera: Pteropodidae) in Kurukshetra district, Haryana, India

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Abstract: The Indian Flying Fox *Pteropus medius* plays a major role in the maintenance of a healthy ecosystem and is very specific in selecting roosting sites. The present study was conducted from January 2021 to March 2022 to document the occurrence of roosting colonies, the roosting sites and the population characteristics of *P. medius* in Kurukshetra district, Haryana. Of the 10 roosting sites identified in four tehsils of Kurukshetra district, 60% were located close to water sources, 20% were near agricultural fields, and the remaining sites were in roadside plantations. Eight roosting sites were observed to be permanent and two were temporary. A total of 233 trees belonging to seven families, eight genera, and nine species were identified as roost trees for this species. Our survey results show that *P. medius* preferred (77.42%) roosting majorly on trees of the Myrtaceae family (*Eucalyptus*), while very few individuals (0.5%) were recorded on *Phoenix dactylifera*. A positive Pearson correlation between the population of the roosting bats and the roost tree characteristics such as height ($r = 0.320$, $p < 0.001$), dbh ($r = 0.226$, $p < 0.001$), and circumference ($r = 0.293$, $p < 0.001$) was also observed. The findings of the current study revealed that *P. medius* prefers to roost on tall trees with large diameters at breast height, located near water bodies and agricultural fields. Protecting such large and tall trees would benefit the conservation of roosting sites of this species and its populations.

Keywords: Bats, circumference, colony, correlation, diameter at breast height, habitat, height, population, trees, water bodies.

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Author contributions: PK conceived and designed the study as well as wrote the final draft of the manuscript. RD performed the field surveys, analysed the data and prepared the rough draft of the manuscript. Both authors read and approved the final manuscript.

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INTRODUCTION

Bats belong to the order Chiroptera, which is the main contributor to mammalian diversity with over 1,455 species distributed all over the World (Simmons & Cirranello 2023) except for the Arctic, Antarctic, extreme desert areas, and a few isolated oceanic islands. Chiropterans are unique in being the only mammals capable of powered flight like Aves (Anderson & Ruxton 2020; Mishra et al. 2020). The order Chiroptera is divided into two suborders – Yinpterochiroptera (Pteropodidae and Rhinolophidae) and Yangochiroptera (Microchiroptera excluding Rhinolophidae) (Simmons & Cirranello 2023). Pteropodidae is the only one of them that lacks laryngeal echolocation capacity (Nojiri et al. 2021) and instead relies on eyesight and smell detection abilities to locate food (Teeling et al. 2002). The latest checklist enumerated 136 species of bats in India (Srinivasulu et al. 2023) accounting for more than 90% of the overall diversity of bats in South Asian countries (Mishra et al. 2020). Among the 12 species of fruit bats occurring in India, three species occur commonly and are distributed throughout the country: *Pteropus medius*, *Rousettus leschenaultii* and *Cynopterus sphinx* (Srinivasulu et al. 2023).

The Indian Flying Fox *Pteropus medius* is one of the largest fruit bats in the world and belongs to the family Pteropodidae (Mishra et al. 2020). This species is largely found in southern Asia and widely distributed in India. *P. medius* is a social species that typically roosts in large colonies of hundreds to thousands of individuals on large and tall trees (Roy et al. 2020). Fruit bats display insightful selection of roosting site exhibiting a preference for particular biotic, abiotic, and geographical factors, their roosting choices are intricately linked to both flora and various environmental variables exhibiting a strong association with specific ecological conditions (Gulraiz et al. 2015). Bat roosting sites in both rural and urban areas are found in a variety of habitats, viz., close to agricultural fields, ponds, temples, and human habitats such as public parks, home gardens, industrial areas, and by the sides of roads (Raza & Ilyas 2018; Madala et al. 2022). The roosting locations range from dense foliage to open areas with large trees which may help in ease of flight, providing shelter from strong winds and support in thermoregulation (Pandian & Suresh 2021). They are animals of considerable economic importance and are crucial for the survival of more than 114 plant species in the world (Aziz et al. 2021). Indian Flying Foxes are integral to ecosystem functioning, performing crucial role such as pollination, seed distribution, and nutrient

cycling (Fujita & Tuttle 1991; Goveas et al. 2006; Kumar & Elangovan 2019; Madala et al. 2022). Globally, *P. medius* has been listed as 'Least Concern' in the IUCN Red list of Threatened Species (Tsang 2020) and is included in Schedule II under the Wildlife (Protection) Amendment Act, 2021 of India. However, the numbers of individuals are decreasing constantly (Dey et al. 2013; Raza & Ilyas 2018) due to the loss of habitat, felling of trees, electrocution, scarcity of food sources, expansion of highways, construction of buildings, public disturbances, and hunting (Chakravarthy & Yeshwanth 2008; Ali 2010), and its role as seed disperser, pollinator and forest regenerator is ignored (Gulraiz et al. 2015).

To survive successfully, all animals require food and shelter, which means the bats need to find an appropriate place to roost. Diurnal roost site selection is a part of habitat selection that affects an animal's ability to survive and reproduce. The daytime roost site is where *P. medius* spends about half of its life for activities like copulation, rest, maternal care, social interactions, and to escape from adverse weather and predators (Kumar & Elangovan 2019). Hence, a study on the bat's ecology, their habitats, and diurnal roosting requirements is the first step toward their effective conservation. No detailed research studies have been carried out on the roosting habits and habitats of *P. medius* in Haryana; hence, to fill up this research gap, the current study was conducted to identify *P. medius* roosting colonies and to document the roost tree characteristics in the Kurukshetra district of Haryana.

MATERIALS AND METHODS

Study area

The study was conducted in all the four tehsils/blocks (Pehowa, Thanesar, Ladwa, and Shahbad) of Kurukshetra district in Haryana state, northern India. Kurukshetra is situated at 29.969° N and 76.878° E at an elevation of 260 m and has an area of 1,530 km² (Figure 1). Kurukshetra is one of the agriculturally advanced districts of the state of Haryana, India. Agricultural activities of the district are dependent on tube wells and canals. Rice-wheat cropping system dominates with the consequent marginalization of pulses and oilseed. Sugarcane is also being grown in the study area as a cash crop. The district is devoid of any perennial river. The river Markanda flows in the northwestern part of the district which originates in Nahan hills. The Yamuna River flows along the eastern and northern boundaries, respectively. The popular Sutlej-Yamuna-Link canal

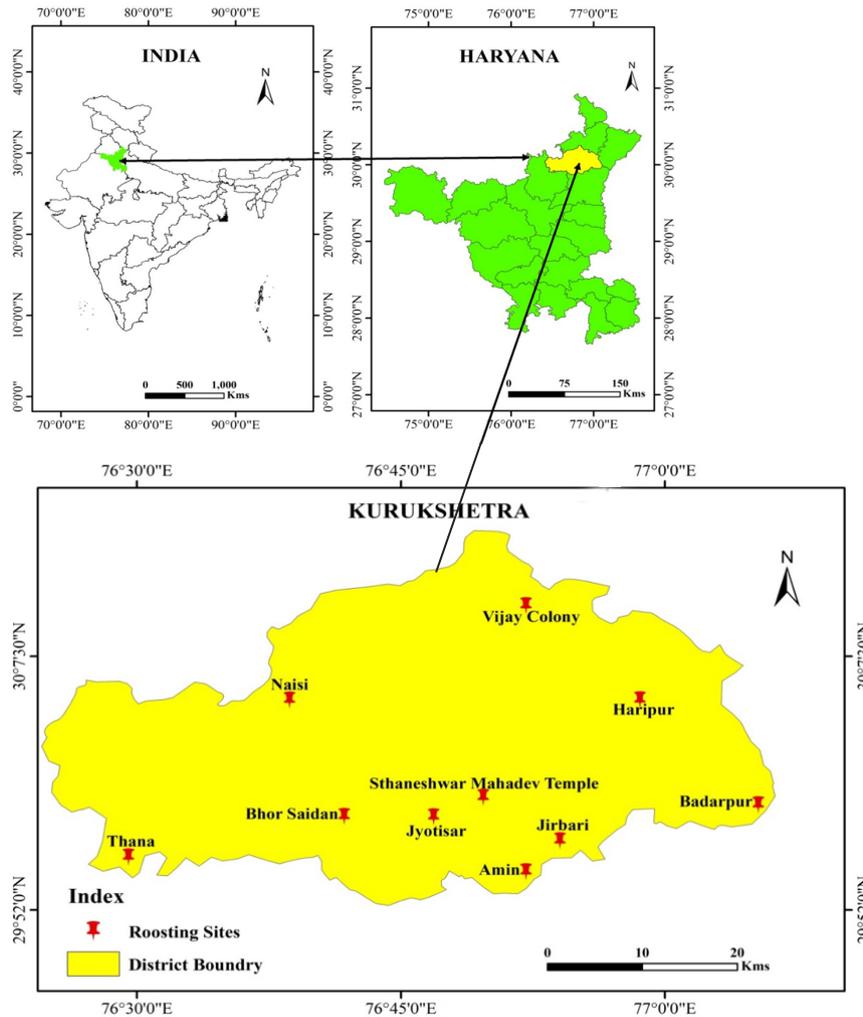


Figure 1. Map of Kurukshetra district, Haryana, with locations of roosting sites.

joining the Sutlej and Yamuna flows across Kurukshetra. Narwana canal which is a branch canal of Bhakra passes through Kurukshetra and is considered as the lifeline of the Haryana state. The soil is generally alluvial loam and clay does not constitute the average texture of the soil. The district has rich potential for the development of horticulture. Major fruit varieties grown in the district are mango, guava, citrus, ber, sapota, and pear/plums. The study area experiences a sub-tropical climate and has three distinct seasons: Rainy (July–September), cool and dry (October–February), and hot dry (March–June). The normal annual rainfall of the district is 582 mm which is unevenly distributed over the area and temperature ranges 3–45 °C.

Data collection

Initially, field surveys were conducted in the study area from January 2021 to March 2021 in Kurukshetra

district to identify the roosting sites of *P. medius*. Initial information regarding the roosting sites was collected through direct interaction/oral inquiry with villagers, and people from the surrounding areas of the study area were also consulted. The identified roosting sites were surveyed every month from April 2021 to March 2022 to collect data on roost characteristics and colony size of *P. medius*. The number of bats at each roosting site was counted by direct roost count method (Kunz et al. 2009) with the help of field binoculars (Nikon 8 x 40) and photographed with a Canon SX-70 camera. The geo-coordinate of each roosting site was recorded using Garmin Etrex 30x GPS (hand-held device). Arc GIS 10.8 was used to prepare the roost distribution map of *P. medius* in the study area. Various parameters of the roosting tree such as species of the tree, origin (exotic or native), circumference, diameter at breast height (dbh) and tree height were recorded early in the morning/

before the arrival of Indian Flying Fox at the roost. The trees used for roosting were identified to species level. The circumference of the roost tree was measured using a measuring tape. To measure the dbh of the trees, the girth (g) of the tree at breast height was measured with a measuring tape, and then the diameter at breast height (dbh) was calculated by the formula $dbh = g/\pi$. The height of the roost tree was measured by using a clinometer (Hahn et al. 2014). Data on the number of the trees used by bats at a roost, type of the roost (permanent/ temporary), habitat of each roosting site (i.e., near water bodies, agricultural fields or roads), and the status of the roost were also recorded.

Statistical Analysis

The information regarding the number of bats, number of trees, height of roost tree, dbh, and circumference of trees were compiled in MS-Excel followed by data analysis and interpretation. Roost tree characteristics (height, circumference, and dbh) were considered as independent units for statistical analysis and thus Pearson correlation analysis was carried out to check the relationship between (SPSS 2007):

1. The bat abundance (colony size per tree) and height of the roost tree
2. The bat abundance and dbh of the roost tree
3. The bat abundance and circumference of the roost tree

All the analyses were performed in the statistical package for social science (SPSS software version 26.0).

RESULTS

A total of 10 roosting sites of *P. medius* were identified during the study period in Kurukshetra district, Haryana. The location, geo-coordinates, elevation, distance from nearest water bodies, number of roost trees, colony size, type of the roost, habitat and status of the roosting site are given in Table 1. Six roosting sites (Thana, Bhor Saidan, Jyotisar, Amin, Sthaneshwar Mahadev temple, and Badarpur) were located near to the water bodies (pond n = 1; water channel n = 3; and canal n = 2) (Image 1), two roosting sites (Naisi and Vijay Colony) were close to agricultural fields (Image 2) and the remaining two (Jirbari and Haripur) were located in road-side plantations (Image 3). Among the recorded roosting sites, two roosting sites (Amin and Sthaneshwar Mahadev temple) were used by bats as temporary roosts because the bats were found to use these roosts only during certain months of the year (April–July, November–

March at Amin; August–November, February and March at Sthaneshwar Mahadev temple) and the remaining eight roosting sites were used as permanent roost during the study period. Bats undertook local migration during peak mating season at Amin roosting site, and in peak summer and winter months at Sthaneshwar Mahadev temple to more favorable roosts where large aggregation of individuals occurred. Migration during peak summer and winter season may be due to unfavorable temperature and weather conditions in this region. In the study area *P. medius* was found to use both single (aggregation of individuals on a single tree) and dispersed/scattered roosts (aggregation of individuals on different trees at a roosting site). Of the total identified roosts, the Amin was a single roost on the tall *Ficus religiosa* whose well-spread crown accommodated a modest number (minimum colony size) of Indian Flying Foxes, whereas nine roosts (Thana, Bhor Saidan, Naisi, Jyotisar, Sthaneshwar Mahadev temple, Jirbari, Haripur, Vijay Colony, and Badarpur) were dispersed roosts (Table 1).

A total of 233 trees belonging to seven families, eight genera and nine species were used as roost trees by *P. medius* in the study area. The roost tree species in the study area included Neem *Azadirachta indica*, Peepal *Ficus religiosa*, Banyan *Ficus benghalensis*, Jamun *Syzygium cumini*, Red Silk Cotton *Bombax ceiba*, Flame Tree *Delonix regia*, Date Palm *Phoenix dactylifera*, Indian Elm *Holoptelea integrifolia*, and Forest Red Gum *Eucalyptus tereticornis* (Image 4). The roost sites of Indian Flying Fox in the study area comprised a minimum of one tree species (Amin) to a maximum of eight tree species (Bhor Saidan). As far as the number of trees in a diurnal roost is concerned, a minimum of one tree was observed at Amin roost whereas a maximum of 45 trees were recorded in the roost at Vijay Colony, Shahabad. Thus, *P. medius* did not maintain any consistency in roost tree selection in the Kurukshetra district. Among the nine tree species identified as roost trees of *P. medius*, seven are of native origin and two of exotic origin (Table 2). Of the 233 roost trees, *Eucalyptus tereticornis* of Myrtaceae family was used as roost predominantly (n = 163), followed by *Holoptelea integrifolia* (n = 32), *Syzygium cumini* (n = 14), *Azadirachta indica* (n = 6), *Ficus religiosa* (n = 6), *Phoenix dactylifera* (n = 5), *Bombax ceiba* (n = 3), *Delonix regia* (n = 2), and *Ficus benghalensis* (n = 2) (Figure 2).

The height of the roost trees varied from 5.4 m (*Azadirachta indica*) to 34.6 m (*Eucalyptus*) with a mean height of 25.72 m. The mean dbh of the roost tree was found to be 53.58 cm ranging from 40.0 cm

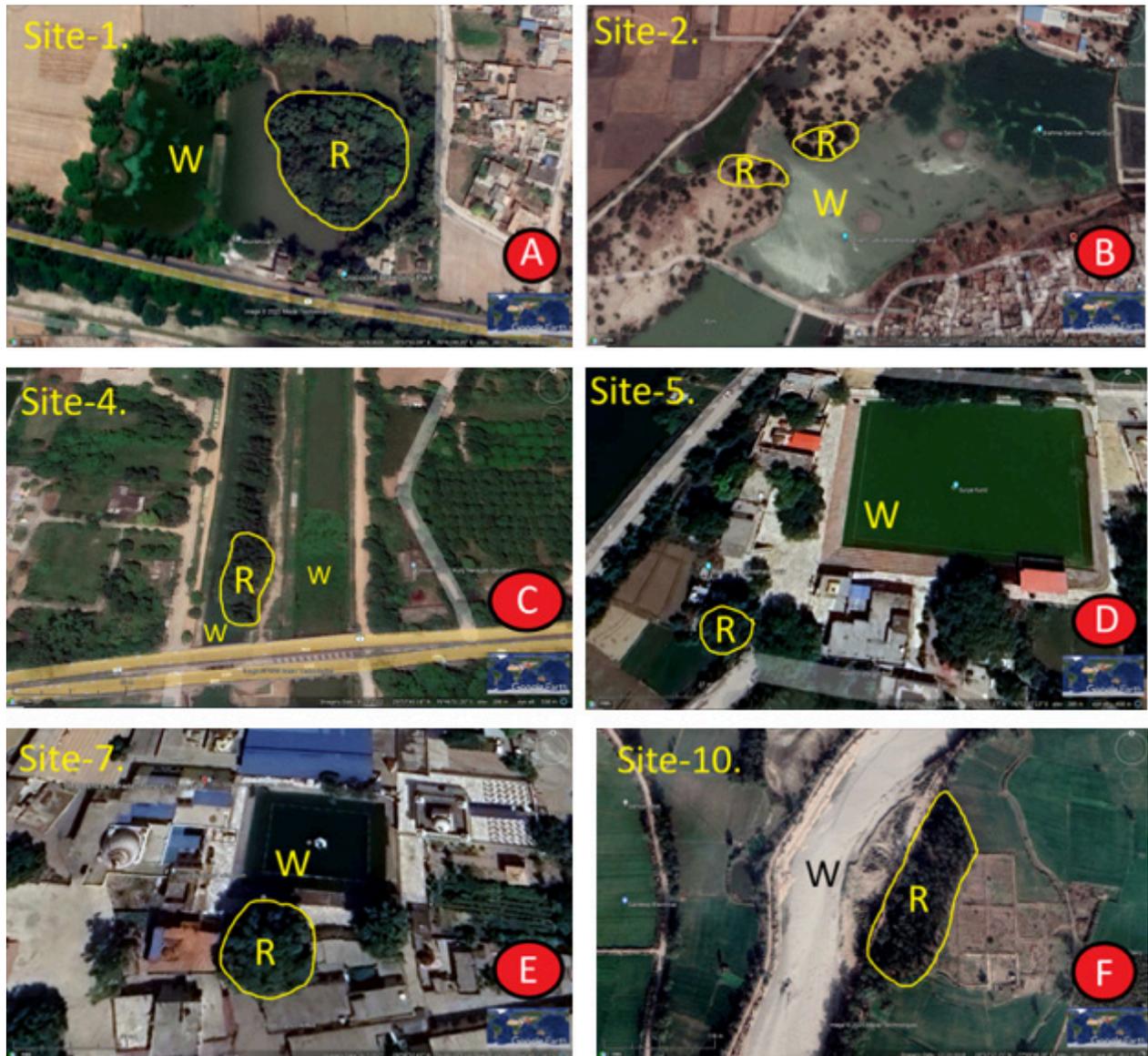


Image 1. Study area map showing various roosting sites which are located near water bodies in Kurukshetra district (R indicates the roosting site and W indicates water body).

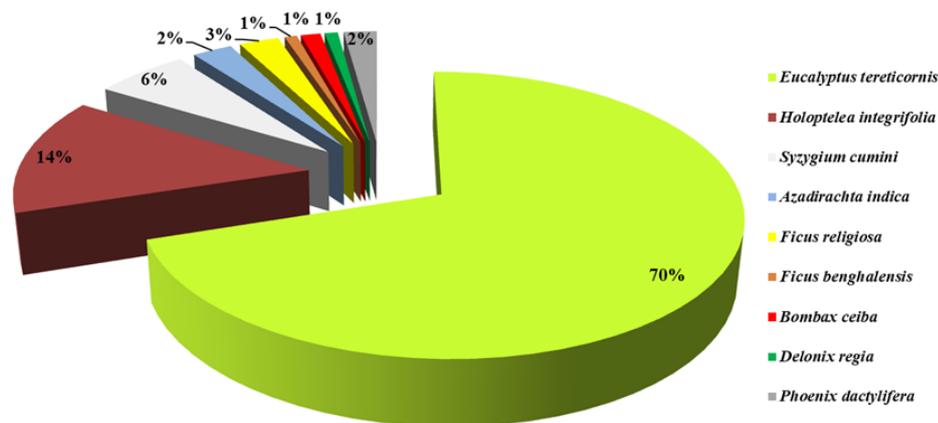


Figure 2. Roost tree diversity used by *Pteropus medius* in Kurukshetra district.



Table 1. Distribution of roosting sites and average population size of Indian Flying Fox *Pteropus medius* in Kurukshetra district, Haryana.

Tehsil	Location of the roosting site	Coordinates	Elevation (m)	Distance from nearest water body	Colony size (M ± SE)	No. of roost trees	Type of roost	Habitat of roost	Status
1. Pehowa	Bhor Saidan	N 29.920284 E 76.492825	248	5.01 m	529±20.15 (410–642)	44	Permanent & dispersed	At the edge of crocodile breeding center pond in village Bhor Saidan	Relatively safe, rarely disturbed by visitors
2. Pehowa	Thana	N 29.920121 E 76.495768	258	6.36 m	232.0 ±20.5 (138–369)	22	Permanent & dispersed	At the edge of pond in village Thana	Highly disturbed by human activities
3. Pehowa	Naisi	N 30.079287 E 76.644301	258	730.9 m	356.5±24.9 (198–450)	28	Permanent & dispersed	Near agricultural fields in village Naisi	Relatively disturbed
4. Thanesar	Jyotisar	N 29.962274 E 76.780665	253	4.10 m	174.1±19.9 (78–297)	17	Permanent & dispersed	Between Sutlej Yamuna link canal and Narwana branch	Disturbed by moving traffic
5. Thanesar	Amin	N 29.907035 E 76.870809	258	43.61 m	19.5±4.07 (12–39)	1	Temporary & single	At the edge of surajkund in village Amin	Disturbed by villagers
6. Thanesar	Jirbari	N 29.936747 E 76.900876	258	695.21 m	308.6±22 (176–430)	21	Permanent & dispersed	At road-side plantation on national highway-44	Disturbed by moving traffic
7. Thanesar	Sthaneswar Mahadev temple	N 29.981198 E 76.827961	258	9.1 m	25.5±7.07 (29–61)	3	Temporary & dispersed	In the premises of temple	Religious site, disturbed by visitors
8. Shahbad	Haripur	N 30.086299 E 76.968970	336	663.02 m	297.0±15.9 (192–391)	19	Permanent & dispersed	At road-side plantation on Shahbad-Ladwa road	Highly disturbed by moving vehicles
9. Shahbad	Vijay colony	N 30.176264 E 76.868887	267	471.23 m	882.5±46.6 (660–1238)	45	Permanent & dispersed	Near agricultural fields in Vijay Colony	Undisturbed, relatively safe
10. Ladwa	Badarpur	N 29.957700 E 77.097949	257	89.23 m	748.9±31.4 (562–893)	33	Permanent & dispersed	At the edge of West Yamuna canal in village Badarpur	Undisturbed, safer

(*Delonix regia*) to 201.13 cm (*Ficus benghalensis*). The Pearson correlation analysis showed significant positive correlation between bat abundance (colony size per tree) and the characteristics of the roost tree such as height ($r = 0.320$, $N = 233$, $P < 0.001$) (Figure 3), dbh ($r = 0.226$, $N = 233$, $P < 0.001$) (Figure 4) and circumference of the roost tree ($r = 0.293$, $N = 233$, $P < 0.001$) (Figure 5). Thus, the height, dbh and circumference of the roost trees influence the roosting habits of *P. medius*.

All the identified permanent roosts of *P. medius* in the study area were comprised of only one tree species except at Bhor Saidan roosting site. Hence, data on seasonal variations in preference of roosting tree species were collected only at Bhor Saidan roosting site (Figure 6). In summer, *P. medius* was observed roosting underneath the canopy of the thick foliage of *Syzygium cumini* roosting trees, flapping their wings, while in the winter *P. medius* was observed roosting with closed wings at the edge of the branches of *Azadirachta indica* roosting trees.

A total of 42,892 individuals of *P. medius* were observed across 10 roosting sites in the Kurukshetra district during the study period. The maximum colony size comprising 10,591 individuals was recorded at Vijay Colony, Shahbad, and the minimum colony size (234 individuals) was observed at Amin roosting site (Figure 7). The colony size of *P. medius* fluctuated between seasons and was recorded to be higher in winter than summer at all roosting sites (Figure 8).

DISCUSSION

In the present study, 10 roosting sites of *P. medius* were recorded from Kurukshetra district, Haryana. The observed colonies of bats are comparable to the earlier studies in different regions of India. For instance, Gaikwad et al. (2012) recorded 16 colonies of the Indian Flying Fox in Maharashtra, Talmale (2014) recorded 27 roosting sites in Madhya Pradesh, and Madala et al. (2022) recorded 11 roosting sites in the midland laterite hillocks of northern Kerala. Flying foxes usually have either a permanent diurnal roost (bats are always present although in variable numbers) or a temporary roost (sites that are used only occasionally) (Jenkins et al. 2007). Likewise in the present study, two sites out of the 10 were temporary roosts and eight were permanent roosts. In India and Nepal, the colonies of *P. medius* mostly preferred to choose trees for roosting near human settlements (Chakravarthy et al. 2009; Krystufek 2009; Katuwal et al. 2019) but in the present study, the



Image 2. Study area map showing roosting sites which are located near agricultural fields in Kurukshetra district (AF indicates agricultural fields).



Image 3. Study area map showing roosting sites which are located on road-side plantations in Kurukshetra district (Yellow arrow in image I indicates national highway 44 and in image J indicates Shahbad-Ladwa road).

majority of roosting sites (60%) were observed near water bodies. Rest of the roosting sites were observed near agricultural fields (20%) and on the roadside plantations (20%). These results are in confirmation with previous studies that in Uttar Pradesh (Kumar et al. 2017), 49% of the colonies of *P. medius* were observed near human habitation and 41% of the colonies near water bodies in Tamil Nadu (Dhivahar & Isaac 2018), 90% of the roosting sites were observed near water bodies and the rest 10% were located near agricultural land and residential area, and in the urban areas of Lahore, Pakistan (Gulraiz et al. 2015), the roosting sites were observed near water bodies. The presence of roosting sites near water bodies facilitates the water requirement and thermal balance of bats during hot seasons (Welbergen et al. 2008; Russo & Ancillotto 2015). In our study we observed the bats hovering above the water's surface, dipping their bodies in water to drink, cool themselves, and lick their body hairs for water (Image 5). It has also been reported that certain species, like *P. livingstonii* and *P. alecto* favor roosts next to waterbodies because they provide a humid atmosphere (Granek 2002).

In the present study the Indian Flying Fox roosted on nine species of trees which reflect their flexibility to occupy diverse habitat conditions. These results are consistent with previous records that *P. medius* roost on different species of trees in India (Chakravarthy & Yeshwanth 2008; Bhatnagar & Salvi 2011; Timalisina & Ghimire 2011; Dey et al. 2013; Ali 2014; Manandhar et al. 2018; Mishra et al. 2020; Madala et al. 2022). *P. medius* has been known to use 22 species of trees as their roost in 20 districts of Uttar Pradesh (Kumar & Elangovan 2019), nine species of avenue trees in Delhi (Mishra et al. 2020) and seven species of trees in Baghnadi village of district Rajnandgaon, Chhattisgarh.

Pteropus species often choose larger trees for roosting (Gulraiz et al. 2015; Kumar & Elangovan 2019) which provide better protection against unfavorable environmental conditions and updrafts for easier flight (Pierson & Rainey 1992; Granek 2002; Dey et al. 2013). In India, *P. medius* has been reported to prefer *Ficus* spp. for roosting (Srinivasulu & Srinivasulu 2004; Goveas et al. 2006; Chakravarthy et al. 2009; Maruthupandian & Marimuthu 2013; Raza & Ilyas 2018; Mishra et al.

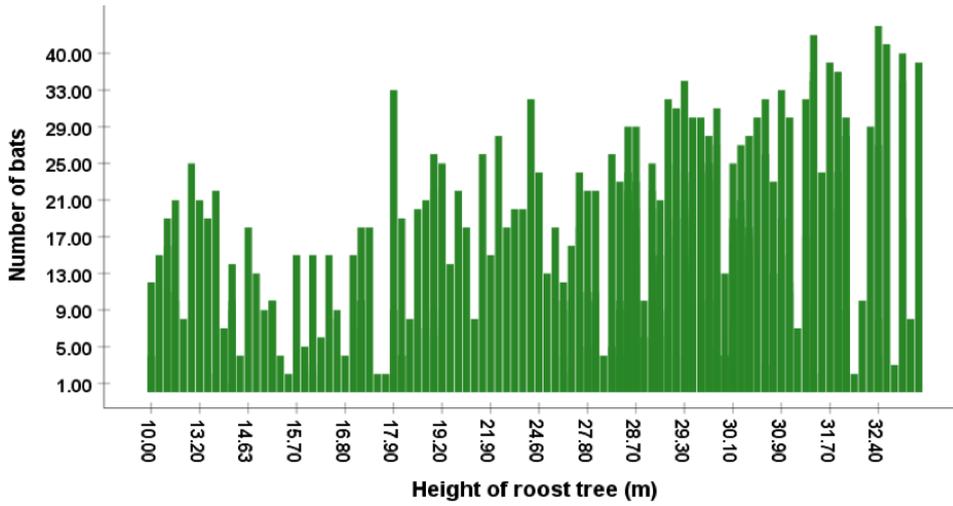


Figure 3. Variation in number of bats roosting with change in height of roost tree.

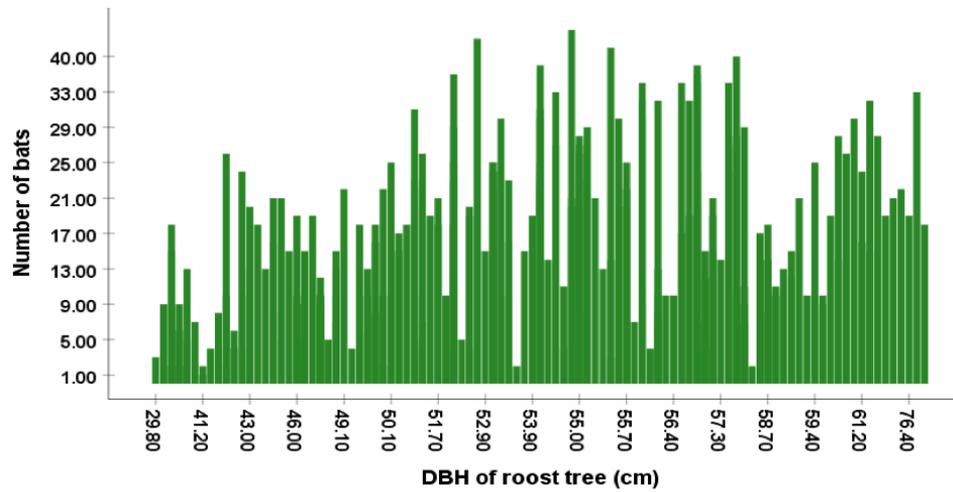


Figure 4. Variation in number of bats roosting with change in DBH of roost tree.

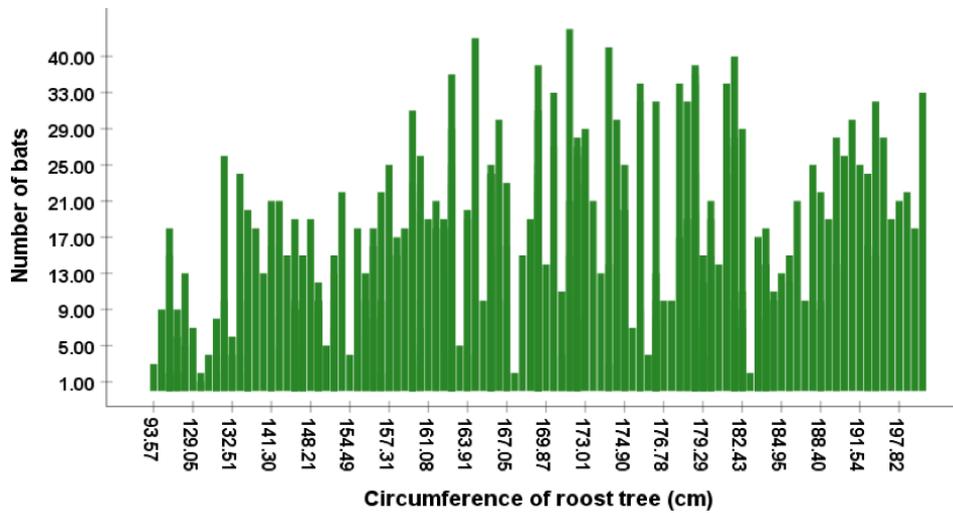


Figure 5. Variation in number of bats roosting with change in circumference of roost tree.

Table 2. Roost tree and roost characteristics of Indian Flying Fox *Pteropus medius* in Kurukshetra district, Haryana.

	Roosting site	Roost tree species			Origin	Circumference (cm)	DBH (cm)	Height (m)	No. of bats
		Family	Scientific name	Common name					
1.	Bhor Saidan	Meliaceae	<i>Azadirachta indica</i>	Neem	Native	190.39±5.10	60.63±1.62	21.06±0.84	137.5±16.5 (52–215)
		Moraceae	<i>Ficus religiosa</i>	Peepal	Native	188.05±12.25	59.89±4.09	17.90±0.37	57.75±3.82 (35–76)
		Moraceae	<i>Ficus benghalensis</i>	Banyan	Native	414.02	131.85	17.20	32.91±4.22 (13–60)
		Myrtaceae	<i>Syzygium cumini</i>	Jamun	Native	136.85±3.69	43.58±0.85	16.70±1.10	141.3±10.6 (86–210)
		Bombaceae	<i>Bombax ceiba</i>	Red Silk Cotton	Native	132±0.80	42.06±0.94	24.60±2.90	55.25±7.08 (21–90)
		Fabaceae	<i>Delonix regia</i>	Flame Tree	Exotic	130.31±4.71	41.50±1.50	19.10±0.30	34.41±6.31 (12–79)
		Arecaceae	<i>Phoenix dactylifera</i>	Date Palm	Native	131.37±2.88	41.84±0.91	18.90±0.60	19.83±5.22 (5–64)
		Ulmaceae	<i>Holoptelea integrifolia</i>	Indian Elm	Native	160.3±18.2	42.58±1.02	15.70±0.70	51.33±6.72 (12–80)
2.	Thana	Ulmaceae	<i>Holoptelea integrifolia</i>	Indian Elm	Native	185.90±1.36	59.20±0.43	8.17±1.45	232.0±20.5 (138–369)
3.	Naisi	Myrtaceae	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Exotic	180.57±1.23	57.29±0.34	30.05±2.46	356.5±24.9 (198–450)
4.	Jyotisar	Myrtaceae	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Exotic	161.91±3.21	51.56±1.02	29.37±3.35	174.1±19.9 (78–297)
5.	Amin	Moraceae	<i>Ficus religiosa</i>	Peepal	Native	240.79	76.50	13.24	19.5±4.07 (12–39)
6.	Jirbari	Myrtaceae	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Exotic	176.55±1.49	56.22±0.47	29.10±1.93	308.6±22.0 (176–430)
7.	Sthaneshwar Mahadev temple	Meliaceae	<i>Azadirachta indica</i>	Neem	Native	212.8	67.51	5.40	1.25±0.42 (1–4)
		Moraceae	<i>Ficus religiosa</i>	Peepal	Native	214.4	68.15	6.40	9.25±2.49 (12–21)
		Moraceae	<i>Ficus benghalensis</i>	Banyan	Native	216.2	68.71	14.63	18±4.75 (16–41)
8.	Haripur	Myrtaceae	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Exotic	157.54±3.12	50.17±1.00	28.30±1.72	297±15.95 (192–391)
9.	Vijay Colony	Myrtaceae	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Exotic	163.53±1.82	52.08±0.58	29.07±3.47	882.5±46.6 (660–1238)
10.	Badarpur	Myrtaceae	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Exotic	164.65±1.63	52.17±0.52	25.90±3.31	748.9±31.4 (562–893)

2020). However, in the present study area, *Eucalyptus* was found to be the preferred roosting tree species for *P. medius*. It might be due to the reason that the *Eucalyptus* tree is branched and taller than other tree species in the area which provided more exposure to sunlight for warming the body. The preference of flying foxes in taller trees may be due to the aerodynamic advantages offered by larger trees, facilitating smoother take-off and landing. Additionally, towering trees may serve as a protective refuge, shielding the flying foxes from human-induced threats (Granek 2002; Gulraiz et al. 2015). The results of the present study support previous observations made elsewhere that *P. medius* prefers to roost in trees with increased dbh (Hahn et al. 2014; Kumar & Elangovan 2019; Madala et al. 2022) and increased height (Kumar & Elangovan 2019; Madala et al. 2022). Trees with increased height normally develop

increased dbh (Metzger 1893). Trees with increased dbh and circumference are long-lasting, and have more ability to resist heavy rain, wind, and drought conditions (Madala et al. 2022).

Among the nine tree species used as roosts, seven species were native and two species were exotic, clearly depicting the preference toward native trees for roosting by *P. medius*. Earlier studies also reported that *Pteropus* spp. prefer native trees for roosting and feeding (Granek 2002; Gulraiz et al. 2015; Madala et al. 2022).

The number of individuals of *P. medius* per colony was found to vary in different areas. In Jambughoda Wildlife Sanctuary, Gujarat a colony of 11,000 individuals was observed (Vyas & Upadhyay 2014), in Odisha the colony size of Indian Flying Fox ranged 43–6,141 individuals (Rao & Poyyamoli 2017), in Delhi the peak colony size of 1,660 individuals were recorded (Mishra et al. 2020) and

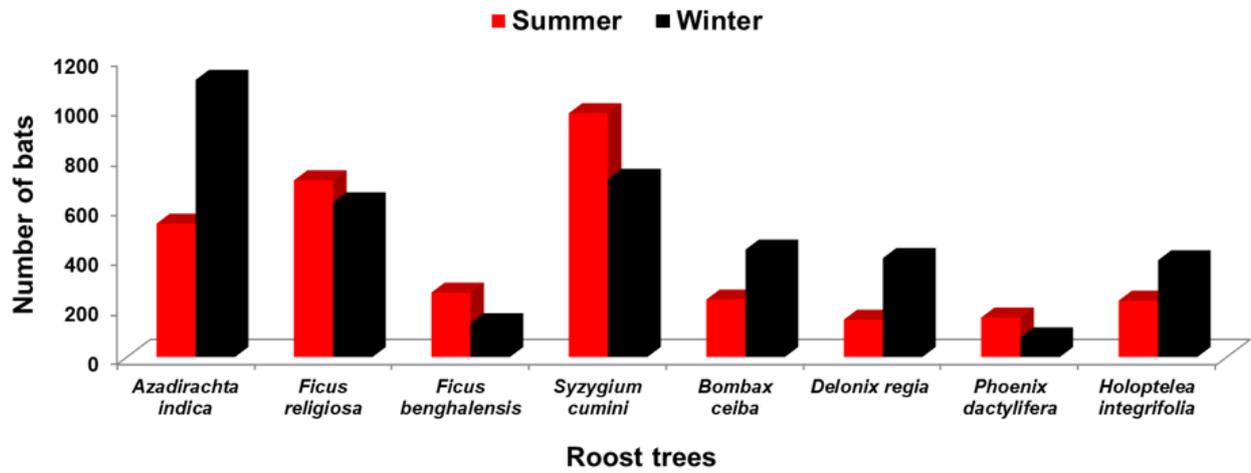


Figure 6. Roosting variation of *Pteropus medius* in different seasons in Kurukshetra district.

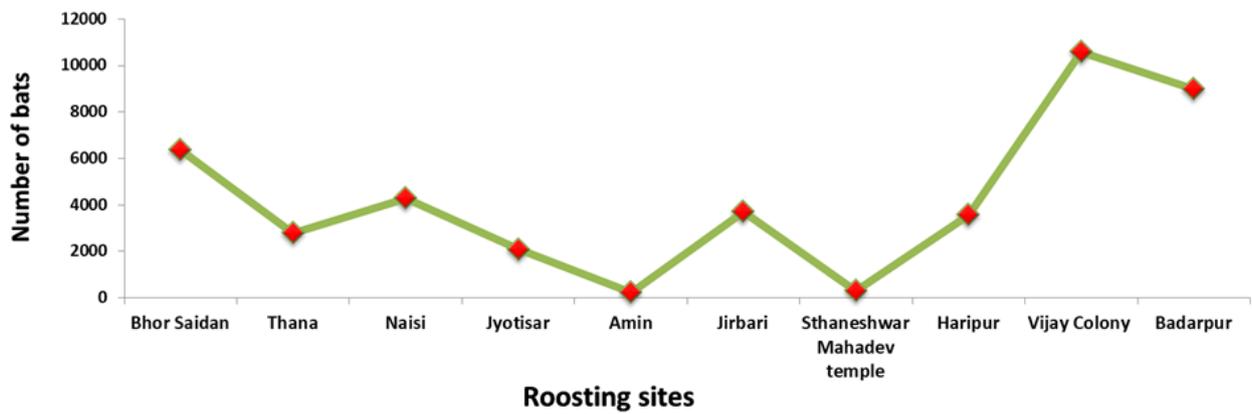


Figure 7. Colony size of *Pteropus medius* at different roosting sites in Kurukshetra district.

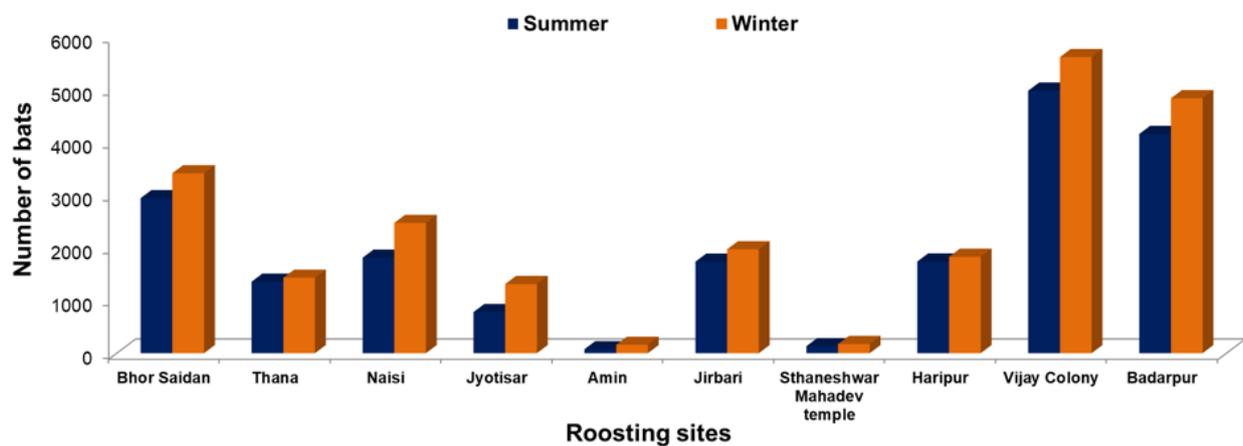


Figure 8. Roosting variation of *Pteropus medius* in different seasons in Kurukshetra district.



Image 4. Details about the roost trees preferred by *Pteropus medius* in Kurukshetra district: A—Neem *Azadirachta indica* | B—Peepal *Ficus religiosa* | C—Banyan *Ficus benghalensis* | D—Jamun *Syzygium cumini* | E—Red Silk Cotton *Bombax ceiba* | F—Flame tree *Delonix regia* | G—Date Palm *Phoenix dactylifera* | H—Indian Elm *Holoptelea integrifolia* | I—Forest Red Gum *Eucalyptus tereticornis*. © Ritu Devi.



Image 5. *Pteropus medius* hovering above the water's surface to cool themselves during warm hours of the day. © Ritu Devi.

in the present study area the colony size of Indian Flying Fox ranged 234–10,591 individuals.

CONCLUSION

The current study revealed the occurrence of various roosting sites, roost characteristics, and populations of *P. medius* in Kurukshetra district. A total of 10 roosting sites were observed in four tehsils of Kurukshetra district. The majority of roosting sites (60%) were located near water bodies. The wide distribution of *P. medius* showed that Kurukshetra district has suitable habitats for its continued survival. The result of the present study showed that *P. medius* roost on open tree branches of different types of roosting trees which reflects their flexibility to occupy diverse habitat conditions that provide many advantages to the bats like protection from human interference, thermoregulation, and enable them to take-off and land more easily. The highest colony size of bats was observed in Vijay colony, Shahbad which showed the presence of maximum number of roost trees compared to other roosting sites. Thus, the population of *P. medius* was also linked with the number of roost trees which provides better protection for their survival and reproduction. It can be concluded from the present study that *P. medius* prefers to roost near water bodies, on tall trees with relatively larger diameters and these are the key factors affecting their distribution. For long-term protection of *P. medius*, further research needs to be undertaken in the study area along with creating awareness among the public on the ecological and economic significance of bats. Future studies on the distribution and conservation of *P. medius* in Kurukshetra area may benefit from the findings of the current study.

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