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Distribution and Roost Selection of the Indian Flying Fox (*Pteropus giganteus*) in Bhavnagar and Ghogha taluka, Bhavnagar, Gujarat.

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Abstract:
The Indian Flying Fox (*Pteropus giganteus*) is a keystone species that provides essential ecosystem services through pollination and seed dispersal. Despite its ecological importance, specific data regarding its roost selction and habitat characteristics in certain regions, such as Gujarat, remains scarce. This study investigated the distribution, population dynamics, and roost tree preferences of *P. giganteus* across 15 sites in the Bhavnagar and Ghogha talukas of Bhavnagar district, Gujarat, from 2020 to 2022.
A total of 78 roost trees across 14 species were identified, with a strong preference for large trees featuring wide canopies (76% of occupied trees), most notably *Ficus bengalensis*. Statistical analysis revealed significant positive correlations between colony population size and several factors: the number of trees within a grove ($r = 0.485$), grove size ($r = 0.292$), and tree characteristics such as diameter at breast height (DBH) and tree height. Roost sites were typically located near water bodies (mean distance 165 ± 178 m) to facilitate thermoregulation and drinking.
The study further identified two distinct roost types: breeding camps, where female numbers peaked during the August-September mating season, and non-breeding camps, which served as sites for parturition between February and March. Despite their adaptability to urban and agricultural environments, *P. giganteus* faces significant threats from habitat destruction—specifically the removal of large canopy trees—and anthropogenic factors such as electrocution on power lines. These findings underscore the urgent need for conservation strategies that prioritize the protection of large, long-lived trees and groves to ensure the survival of this persecuted yet vital species.

Keywords: *Pteropus giganteus*, roost selection, roosting ecology, conservation, breeding camps.

1. INTRODUCTION

The genus *Pteropus*, commonly known as flying foxes, is the largest within the Megachiroptera suborder, comprising 186 species globally, with 86 documented across Asia. India is home to approximately 120 bat species, 14 of which are fruit bats. Among these, the Indian flying fox (*Pteropus giganteus*) is one of the most widespread and familiar species, recorded in 26 Indian states.
Bats provide essential ecosystem services, particularly as pollinators and seed dispersers for over 300 plant species in the Old World. Despite their ecological importance, *P. giganteus* is often persecuted and is currently listed as vermin under Schedule V of the Indian Wildlife (Protection) Act 1972. Human activities have led to significant population declines, such as a reported 48% decrease at a single roosting site in Assam over a ten-year period.
Roosting ecology is fundamental to the survival and reproduction of flying foxes, as they spend much of their lifespan in these locations. These bats are colonial, congregating in large groups called "camps" that can range from a few dozen to several thousand individuals. Roost selection is influenced by a complex interplay of biotic, abiotic, and geographic factors. Evolutionary adaptations lead these bats to prefer tall,

emergent trees with wide canopies, which provide protection from threats and facilitate flight. Additionally, proximity to water bodies and human settlements—where they forage in orchards and gardens—plays a significant role in roost site selection.

While *Pteropus* species have been studied extensively, specific information regarding the roost tree characteristics and selection criteria for *P. giganteus* remains limited, particularly in the state of Gujarat. There is an urgent need to reassess the conservation status of this species and recognize the essential ecosystem services it provides. Therefore, this study aims to investigate the distribution, roost tree characteristics, and roost selection of the Indian flying fox (*Pteropus giganteus*) in the Bhavnagar district of Gujarat, India.

2. STUDY AREA

The study area is the Bhavnagar district in the Saurashtra region of Gujarat, India. The research specifically focused on both rural and urban environments within two talukas: Bhavnagar and Ghogha.

2.1 Geographic and Environmental Characteristics

- **Location**: The study area lies between 21.77° N latitude and 72.15° E longitude.
- **Climate**: The region has a hot semi-arid climate with hot, dry summers (peaks up to 41.22°C), wet monsoon season, and mild winters. It remains humid throughout the year due to its proximity to the Gulf of Khambhat.
- **Topography**: The landscape predominantly consists of agricultural land within a coastal zone.
- **Specific Zones**: The Bhavnagar taluka is categorized into three distinct areas:
- **Mudflats and Intertidal Zones**: Areas submerged in seawater with saline soil.
- **Urban Areas**: Featuring the administrative center (Bhavnagar city) with old trees, gardens, and lakes.
- **Agricultural and Rural Areas**: Characterized by a rich diversity of fruit plants and orchards.

2.2 Surveyed Roosting Sites

A total of 15 roosting sites were identified and studied:

- **Bhavnagar Taluka (9 sites)**: Jewels Circle, Malanka, Gundi, Koliyak, Hathab, Thalasar, Railway Colony, Sir P. P. Institute of Science, and Lakhanka.
- **Ghogha Taluka (6 sites)**: Kukad, Bhakhal, Padva, Ukharla, Bhikada, and Valukad.

These sites encompassed various environments, including reserve forests, temple areas, roadsides, private orchards, and government areas. The research highlighted that these roosts were typically located near water bodies (average distance of 165 ± 178 m) and human settlements.

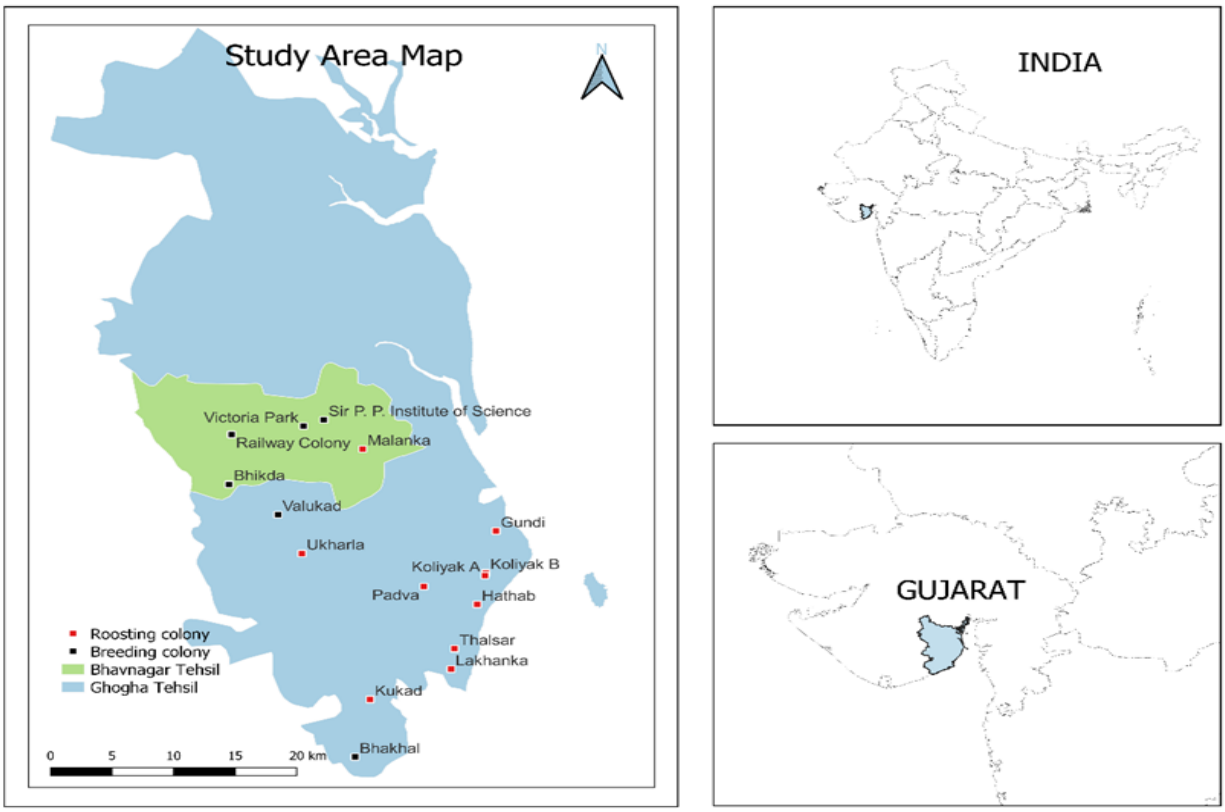

Fig. 1 Map of the Study area.

3. MATERIALS AND METHODOLOGY

Based on the research paper provided, the materials and methodology used to study the distribution and roost selection of the Indian Flying Fox (*Pteropus giganteus*) are as follows:

3.1 Study Period and Area

- **Duration**: The study was conducted over a two-year period from January 2020 to December 2022.
- **Seasonal Divisions**: The study period was categorized into four seasons: winter (December–February), summer (March–May), monsoon (June–September), and post-monsoon (October–November).
- **Location**: Research was carried out in the **Bhavnagar district** of Gujarat, specifically within the Bhavnagar and Ghogha Talukas. The study area encompassed diverse environments including urban areas, rural village limits, agricultural farmlands (orchards), and isolated sites.

Name of roost site	Environment	Protection Information	Lighting patternt	Distance from road (mi)	Distance from water bodies (mi)	Distrubunce
Victoria park	Reserve forest	Protected by government	Semi-dark	300	25	Birds, Human beings
Malanka	Temple area	Protected by local people	Bright light	5	45	Birds, Human beings
Gundi	Road side	Not protected	Semi-dark	25	33	birds, Small mammals
Koliyak	Road side	Not protected	Semi-dark	7	30	Birds, Human beings
Hathab	Private orchard	Not protected	Semi-dark	450	150	Birds, Human beings
Thalsar	Private orchard	Protected by local people	Dark	140	200	Birds.
Railway colony	Government area	Protected by government	Semi-dark	260	70	Birds
Sir P. P. institute	Government area	Protected by government	Semi-dark	220	--	Birds, Human beings
Lakhanka	Private orchard	Protected by local people	Dark	1600	160	birds, Small mammals
Kukad	River side	Not protected	Dark	550	25	birds, Small mammals
Bhakhal	Reserve forest	Not protected	Bright light	180	35	Birds
Padva	Private orchard	Protected by local people	Semi-dark	620	60	Birds
Ukharla	Private orchard	Not protected	Semi-dark	400	40	Birds, Human beings
Bhikda	Dam Site	Not protected	Bright light	970	10	Birds
Valukad	Government area	protected by government	Bright light	350	10	Birds, Human beings

Table. 1 Roost site information of *Pteropus giganteus* in different area

3.2 Data Collection and Surveys

- **Primary Survey**: An initial survey was conducted from January to March 2020 to identify roost sites across the study area.
- **GPS Mapping**: Geographic coordinates for all recorded roosting sites were obtained using a GPS device.
- **Roost Parameters**: Researchers recorded several site-specific parameters, including:
  - The total number of roost sites and individual roost trees·
  - Distances from the roots to the nearest roads, human habitations, and water bodies.
  - The composition of surrounding gardens or orchards.
- **Roost Classification**: Habitats were classified based on their use/non-use by humans and their proximity to settlements (Isolated, Rural, Agricultural, or Urban).

3.3 Tree Characteristic Measurements

- **Measurement Tools/Standards**: Tree measurements followed the *American Forest Champion Trees Measuring Handbook*.
- **Specific Metrics**: For each roost tree, the following were recorded:
  - **Diameter at Breast Height (DBH)**, **Tree Height**, **Canopy Width.**
- **Comparative Data**: Measurements were also taken for adjacent non-roost trees (defined as those with a minimum DBH of 53.14 cm and height of 9.3 m) to compare characteristics with chosen roost trees.

3.4 Population Estimation

- **Counting Methods**: Two methods were used to determine bat population sizes: Tree Estimation for larger colonies and an Exact Count for smaller, more manageable groups.
- **Local Interviews**: The duration of roost occupancy (how many years a site had been used) was gathered through interviews with 215 local residents.

3.5 Statistical Analysis

- **Software**: Data was managed in MS Excel and analyzed using **SPSS software**.

➢ **Methods**:

- Standard protocols were used to measure variances in tree height and DBH between roosting and non-rooting trees.
- A correlation coefficient test was applied to analyze the relationship between population size and factors like grove size, number of roost trees, and specific tree characteristics.
- Statistical significance for all tests was set at **P < 0.05**.

4. RESULTS

During the study, 15 roosting sites of *Pteropus giganteus* were identified across the Bhavnagar and Ghogha talukas. The key findings include:

4.1 Population Size and Distribution:

➢ Colony sizes ranged from **185 to 1150 individuals**, with an average population of approximately 424 individuals.

➢ The largest colony (1150 individuals) was recorded in **Hathab village**, suggesting optimal environmental conditions and food resources.

➢ Most roosts were in rural areas, specifically within agricultural zones.

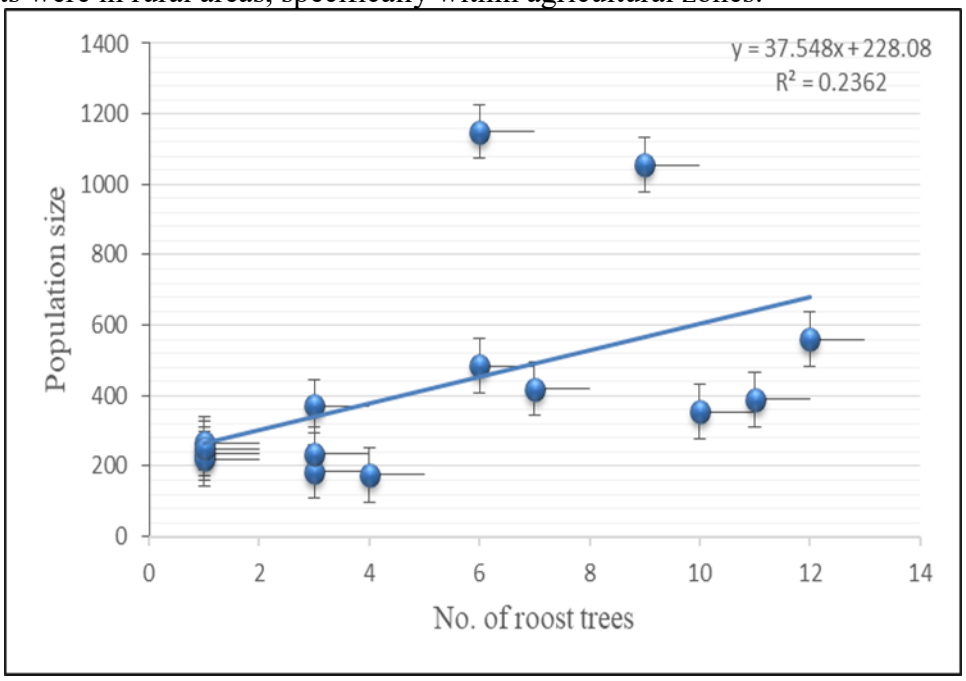

Fig. 2 Relation between roost trees and population size of *Pteropus giganteus.*

4.2 Roost Tree Preferences:

- The bats occupied 14 different tree species, primarily favoring those with **wide canopies (76%)** like *Ficus bengalensis* (Banyan), *Ficus religiosa* (Peepal), and *Tamarindus indica* (Tamarind).
- A significant positive correlation was found between the **colony population size and the number of roost trees** ($r = 0.2362$, $p < 0.05$).
- Roosting trees were significantly taller and had a larger diameter at breast height (DBH) compared to non-roosting trees.

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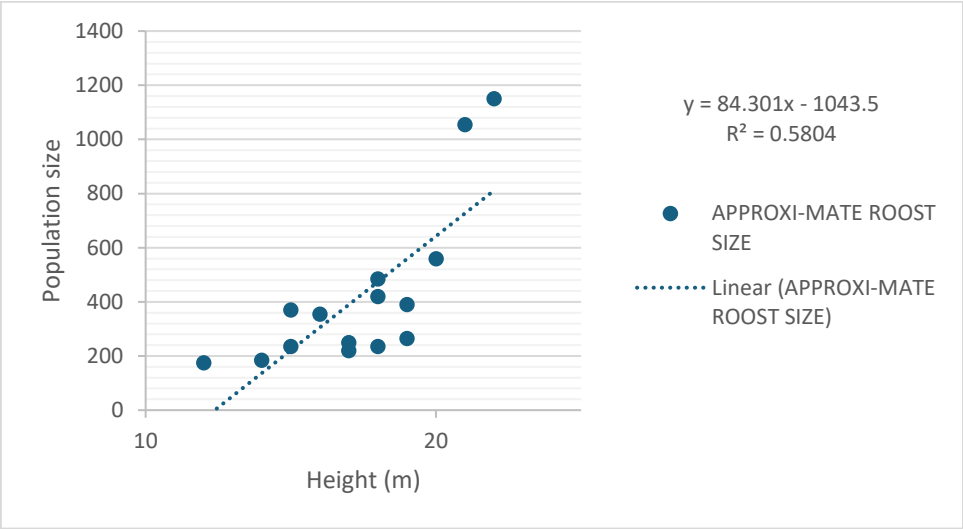

Fig. 3 Height of roosting trees and population size of *Pteropus giganteus*

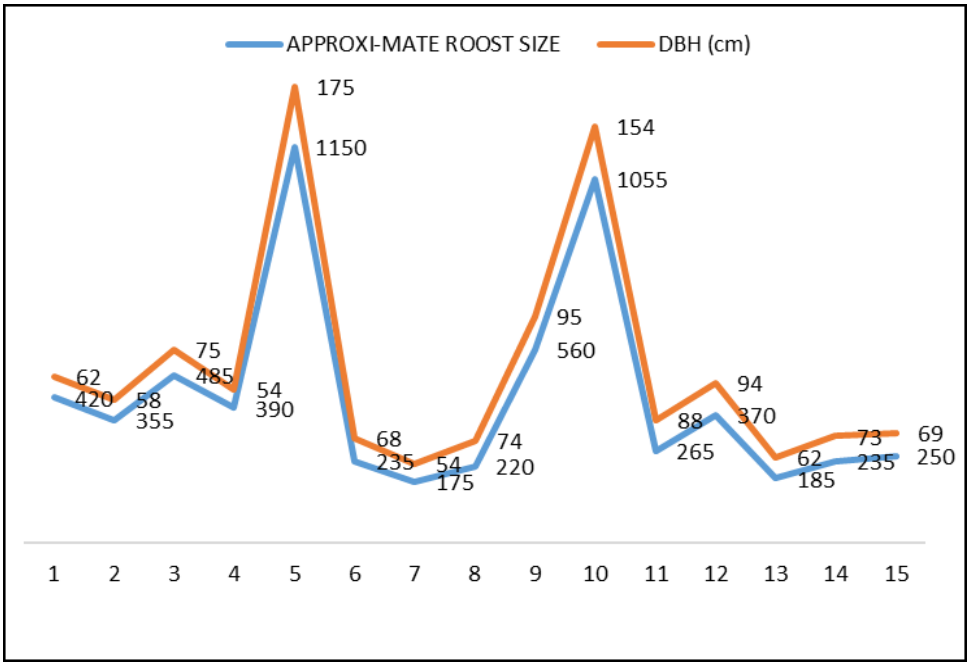

Fig. 4 Dbh of roosting trees and population size of *Pteropus giganteus*

4.3 Environmental Factors:

- All roots were located near water bodies, typically within **205 ± 130 meters** of rivers or ponds.
- The bats showed a strong preference for **groves** over isolated trees; as grove size increased, both the number of roost trees and the population size increased significantly.

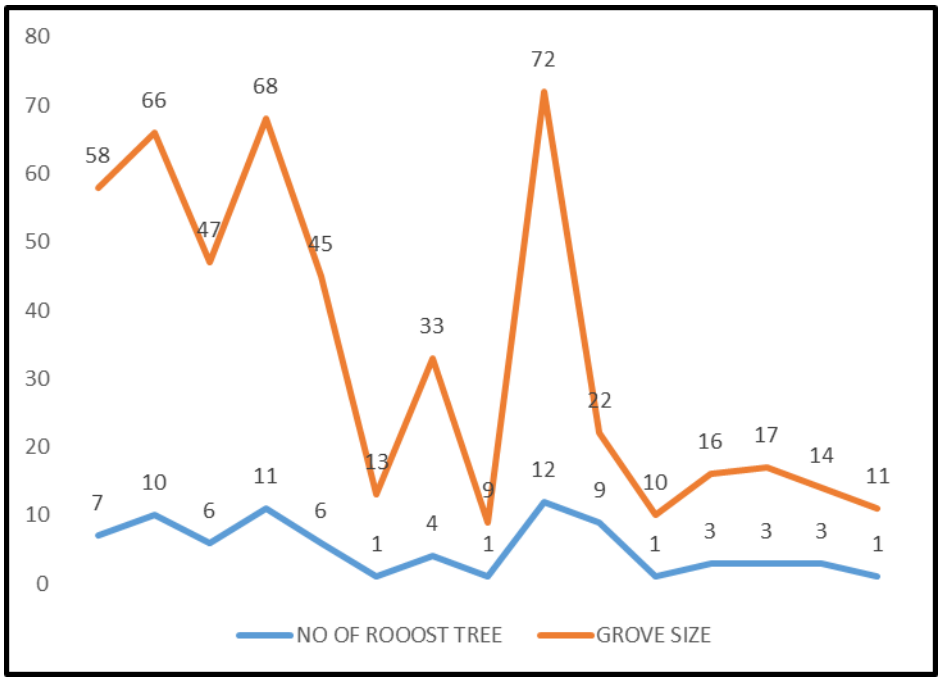

Fig. Fig.5 Grove size and number of roost trees.

4.4 Roost Dynamics:

- The study identified two distinct types of camps: **Breeding camps** (where mating occurs, peaking in August/September) and **Non-breeding camps** (where births occur, peaking between February and March).

5. THREATS IDENTIFIED

- **Habitat Destruction**: Urban development and the removal of large canopy trees like Banyan trees have drastically reduced available roosting resource.
- **Electrocution**: Due to their large wingspan, bats are frequently electrocuted on power lines located near fruit-bearing trees.
- **Predation**: Predators such as kites, snakes, cats, and dogs pose a constant threat.

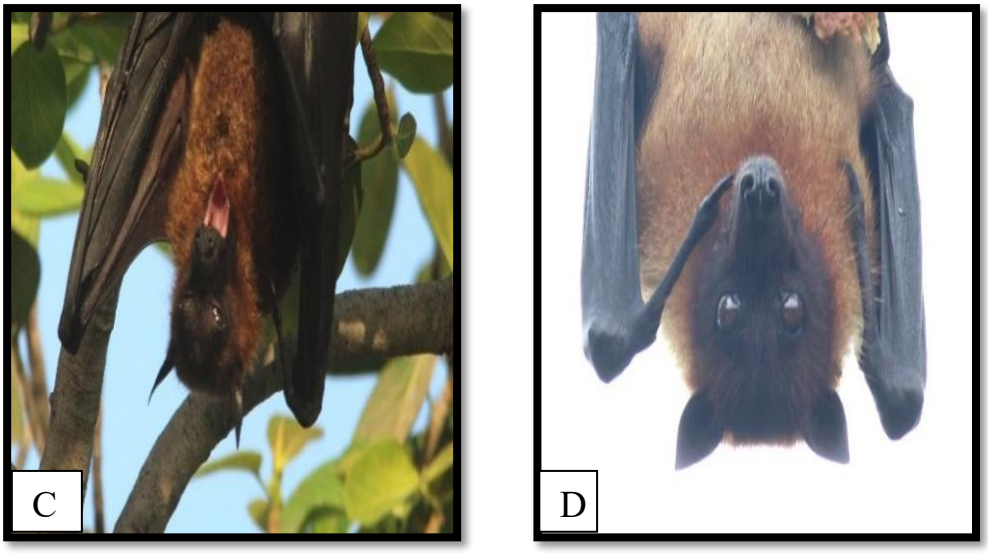

Plate. 1 A glimpse of the dorsal (A), ventral (B) and frontal (C &D) view of the Indian flying fox, Pteropus *Giganteus*

6. DISCUSSION

The habitat occupancy of *Pteropus giganteus* is driven by a complex interplay of geographic, physical, and ecological factors.

- **Selection for Survival and Flight**: The preference for tall trees with high DBH and wide canopies is likely an evolutionary adaptation to ensure protection from environmental hazards and provide necessary updrafts for easier flight.
- **The Importance of Groves**: Living in groves rather than isolated trees offers enhanced shelter from stressors like high winds and extreme temperatures. The positive correlation between grove size and population density emphasizes that these areas provide a stable environment for social and reproductive activities.
- **Thermoregulation**: Proximity to water bodies is crucial for thermoregulation, particularly during hot seasons when bats may need to drink during the day to stay cool.
- **Conservation Implications**: Despite their ecological role as pollinators and seed dispersers, the 48% decline in some populations (as reported in other studies) and their "vermin" status in India highlight an urgent need for habitat protection. Safeguarding large, long-lived trees is essential for the long-term survival of this keystone species.

7. CONCLUSIONS AND FINDINGS

7.1 Roost Selection and Habitat Preferences

- **Tree Characteristics**: The species shows a strong preference for tall trees with wide canopies and high diameter at breast height (DBH). These features provide durability against weather, protection from predators, and ease of flight for take-offs and landings.
- **Favored Species**: *Ficus* trees (Banyan and Peepal) are the most preferred, though they also utilize species like Tamarind, Neem, and Eucalyptus.
- **Proximity to Resources**: Roosts are typically located near water bodies (averaging within ~165m) for thermoregulation and drinking, and near human settlements which provide access to diverse food sources from orchards and gardens.

- **Grove Over Isolation**: The bats rarely roost in isolated trees, preferring groves where population size increases significantly with the number of available roost trees and overall grove size.

7.2 7Population and Breeding Dynamics

- **Colony Structure**: The study identified two distinct types of camps:
- **Breeding Camps**: Sites for mating, where female numbers peak in August and September.
- **Non-Breeding Camps**: Sites for parturition (giving birth), with peaks in parturient bats from October to March.
- **Demographics**: Colony sizes in the study area ranged from 185 to 1150 individuals, with the largest colony found in Hathab village.

7.3 Major Threats and Conservation Needs

- **Anthropogenic Pressure**: Urbanization and habitat fragmentation are the primary threats, specifically the removal of large canopy trees essential for roosting.
- **Accidental Mortality**: The bats are highly vulnerable to **electrocution** on power lines because their large wingspan often exceeds the distance between the wires.
- **Legal Status**: Despite being a keystone species for pollination and seed dispersal, *P. giganteus* is currently listed as "vermin" under Schedule V of the Indian Wildlife (Protection) Act 1972, leading to significant persecution.

8. FINAL RECOMMENDATIONS

The paper calls for an urgent reassessment of the conservation status of the Indian Flying Fox. It emphasizes that protecting large trees and groves is vital for maintaining the health of the local ecosystem through the essential pollination and seed dispersal services these bats provide.

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