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DISTRIBUTION AND ABUNDANCE OF THREE POPULATIONS OF INDIAN FLYING FOX (*Pteropus giganteus*) FROM PURULIA DISTRICT OF WEST BENGAL, INDIA

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Abstract
The present study was carried out to monitor three roost sites of Indian flying fox (*Pteropus giganteus*) populations during the period November 2010 to October 2011 near Purulia, West Bengal, India. At all three sites, bats were found to occupy different tree species (*Eucalyptus* sp., *Dalbergia latifolia*, *Tamarindus indica* and *Terminalia arjuna*) outside villages for day roost sites in close proximity to water bodies. Behavioural observations were made based on all occurrence method where all behaviours observed for duration of 30 minutes was noted during each census for the entire study period. Favourable roosting conditions were found to support higher bat abundance. Moreover, bat abundance and ambient temperature were found to be negatively correlated, and mass die–offs and population decline were recorded in the hotter months of the year (April – July). Study of bat guano revealed aspects of their feeding habits and their pivotal role as seed dispersers. Information from local villagers affirmed that the bat populations occurring at the roost sites are more than a century old and are regarded as sacred. Moreover, no direct conflicts were recorded between the bats and villagers during the present study. According to the villagers bat populations are declining due to road expansion, cutting of trees and hunting by outsider nomads; these aspects need serious attention from the authorities concerned.

***Key words*:** Chiroptera, habitat selection, vermin, behaviour, threats, ecology, conservation

Introduction

The largest non–human aggregations of mammals are formed by bats, which occupy all habitable corners of the earth with the exception of some remote islands and the polar regions (Swamidoss *et al*., 2012). Bats comprises 25% of all mammal species (Mickleburgh *et al.*, 2002) and the recognized

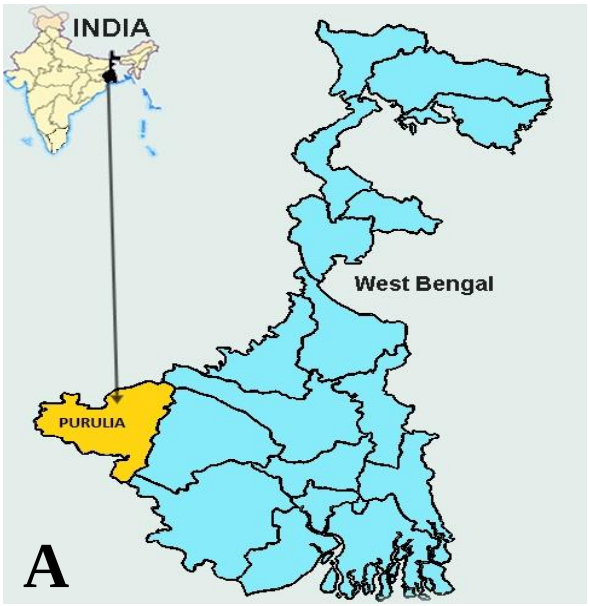
global number of taxa now exceeds 1100 (Simmons, 2005). India is known to have 113 species (Bates & Harrison, 1997). *Pteropus giganteus*, also known as Indian flying fox, is a fruit bat of the suborder Yinpterochiroptera (Teeling *et al.*, 2005). Apart from India this species is also distributed in Bangladesh, Bhutan, China, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka (Molur *et al.*, 2008). *Pteropus giganteus* is a colonial species, which roosts in large trees like *Ficus bengalensis*, *Eucalyptus globulus*, *Mangifera indica* and *Tamarindus indica* (Vendan, 2003).

The large day roost groups of this bat are known as 'camps', which consist of several hundred to several thousand individuals (Eby 1991; Parry–Jones & Augee 1992). These camps are usually found in close association with human settlements both in villages and cities. *Pteropus giganteus* are animals of considerable ecological and economic importance and play a pivotal role in pollination and seed dispersal (Godinez–Alvarez *et al*., 2002; Goveas *et al*., 2006). Few ecological studies of fruit bats have been carried out in the Indian subcontinent, but are now more crucial with the accelerating rate of habitat destruction (Wilson & Engbring, 1992). Although the IUCN Red List of Threatened Species has classified this species as Least Concerned, the numbers of individuals are decreasing consistently (Venkatesan, 2007), primarily due to habitat loss and hunting. Accordingly, some populations are becoming locally Threatened (IUCN, 2012). Moreover, knowledge about their distribution, nesting and roosting habits is rudimentary (Pierson & Rainey, 1992).

Hence, recognizing roost sites and protecting such areas are important for the conservation of decreasing *P. giganteus* populations. The present investigation was carried out for a year to survey three roost sites of *P. giganteus* from Purulia District of West Bengal, India. Fluctuations in numbers of roosting animals at the sites were recorded along with ambient temperature and overall behaviour of the bats, to assess population trends with respect to season. Also, a questionnaire was used to obtain information from the nearby inhabitants on the population trends of the bats over several decades.

Materials and methods

***Study area*:** The present investigation was carried out at three different *P. giganteus* camps in the Purulia District of West Bengal, India. Population at Site 1 (23° 38′ 08.50″ N / 86° 48′ 38.20″ E) was located near Bartoria village on the side of Barakar–Purulia highway. Site 2 (23° 22′ 44.20″ N / 86° 38′ 47.02″ E) was located near Simla village on the side of Adra–Hura road, about 18 km from the busy Adra Railway town. Site 3 (23° 31′ 47.14″ N / 86° 44′ 01.25″ E) was located near Biltora village on the side of Raghunathpur–Bankura state highway. All the colonies were located in close vicinity to water bodies (Fig. 1).



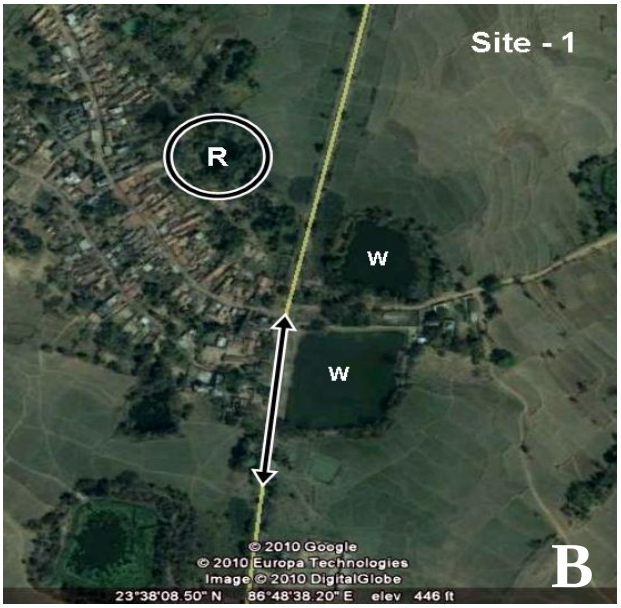


Figure 1: Map showing the study sites under present investigation from Purulia District, West Bengal, India: **A**, General map of West Bengal, with the location of Purulia District; **B**, Study site 1; **C**, Study site 2; **D**, Study site 3. (Circles with 'R' indicates the bat colony roosting site; W = water body; Arrows indicate Barakar–Purulia highway, Adra–Hura road and Raghunathpur–Bankura state highway for Sites 1, 2 and 3, respectively). Distance between the three roost sites: Study site 1 and Study site 2 = 40 km; Study site 2 and Study site 3 = 20 km; Study site 3 and Study site 1 = 25 km.

***Data collection*:** Monthly surveys were conducted for all roosting bats on three consecutive days, one day at each of the three sites between November 2010 and October 2011. To census the bat populations, we applied the direct roost count method (Barlow, 1999) at 08:00, 12:00, and 16:00. Each bat population was counted three times during each sampling using binoculars and a digital camera and numbers were averaged to get a representative value. Additionally bats emerging from the roost sites during sunset were photographed and counted (O'Shea *et al.*, 2003). Observations on bat behaviour were made using binoculars and digital cameras. Ambient temperature was noted throughout the day every time a sampling was done (at 08:00, 12:00, and 16:00) to get a representative mean value. Temperature was recorded using a digital thermometer (CIE310), holding the probe 2 m above ground. Recordings were made both in light and shaded areas near the roosting trees and averaged. The mean value recorded for a single month was crosschecked with data obtained from District Forest Office, Kangsbati Division, Purulia. Fifty to sixty villagers of varying age classes from each village were interviewed independently or in groups of 2 to 3 persons, to obtain information about the feeding behaviour of the bats and their population trends. Guano and other food residues were periodically collected in zip–lock plastic packets and analysed for a better understanding of feeding habits.

***Statistical Analysis*:** Statistical analysis to test for a correlation between bat population size and ambient temperature ($p < 0.05$) was performed using statistical software Statistica for Windows, vers. 5.1A (Statsoft 1996). Graphical plots were made by using SciDAVis release 0.2.0; 2009.

Results

Pteropus giganteus camps observed in the present investigation were found to occupy different host trees in all three sites: site 1, the bat population camped on two trees, one Eucalyptus (*Eucalyptus* sp.) and one Sishu (*Dalbergia latifolia*); site 2, in one large Tamarind tree (*Tamarindus indica*), and site 3, in one Arjun tree (*Terminalia arjuna*) (Fig. 2). The three sites differed in the number of roosting individuals, as well as seasonally. Site 2 supported the highest number of bats, followed by site 1 and site 3. During the hotter months (Apr – July) the number of individuals dropped considerably (Fig. 3). Correlation

matrices revealed a negative relationship ($p < 0.05$) between bat abundance and ambient temperature for all the three sites (where 'r' was calculated as –0.75, –0.56 and –0.39 for site 1, site 2 and site 3, respectively). During the roosting period, individuals displayed different behaviours, including continuous squabbling, cleaning and scratching with claws, fighting for better roosting positions and occasional excretion of faecal matter. Bats fanning wings in the summer and basking with stretched wings in winter were commonly observed. Collected guano samples revealed that they feed on fruits (bananas, mangoes, guava, tamarinds, figs, palms and dates), flower blossoms and leaf buds. Bats were observed to mate from August to October, while infants were born from February to April.

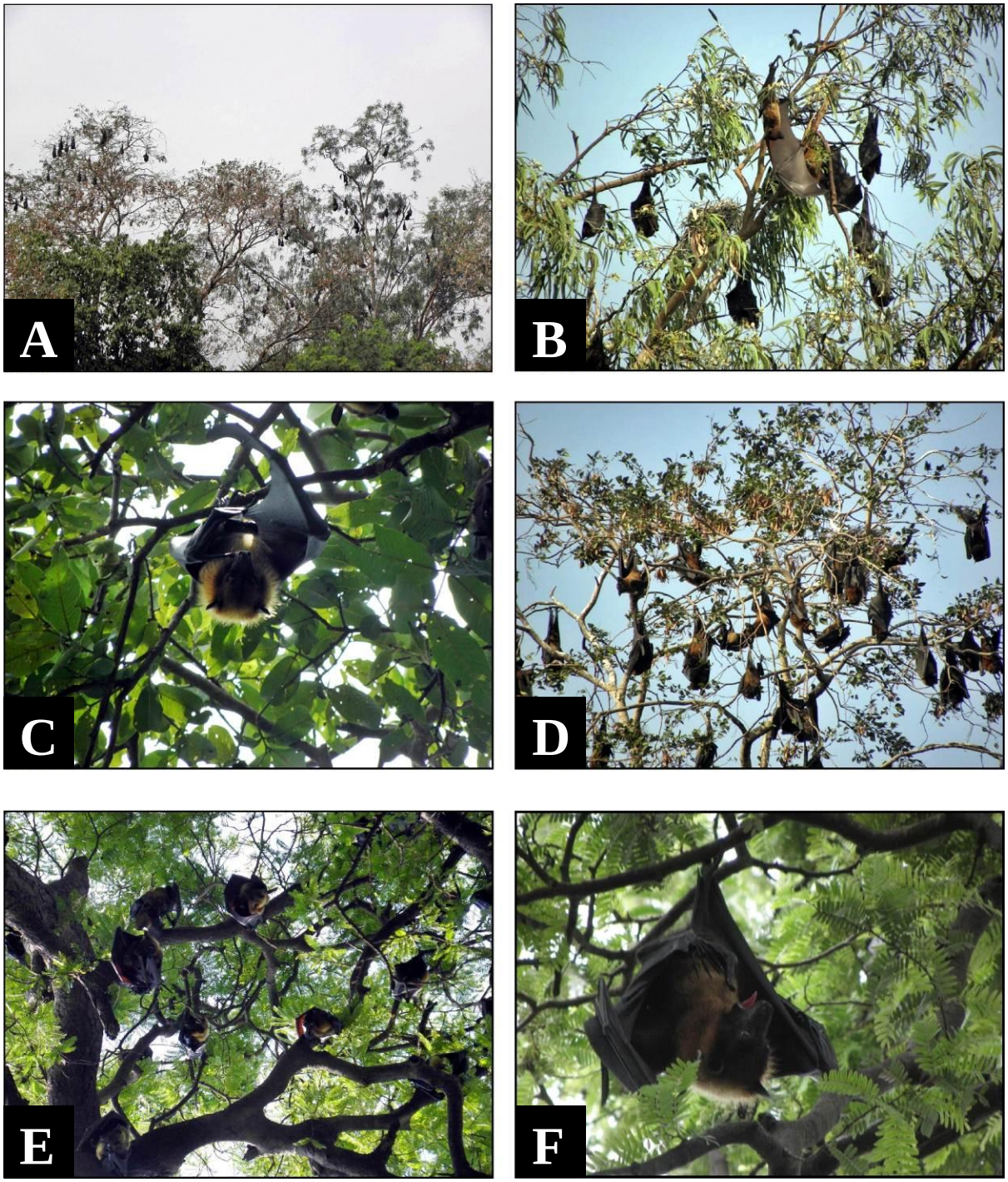


Figure 2: *Pteropus giganteus* colonies from three sites in Purulia District, West Bengal, India: **A** & **B**, population at site 1 occupying *Eucalyptus* sp. and *Dalbergia latifolia* trees; **C** & **D**, population at site 3 occupying *Terminalia arjuna* tree; **E** & **F**, population at site 2 occupying *Tamarindus indica* tree.

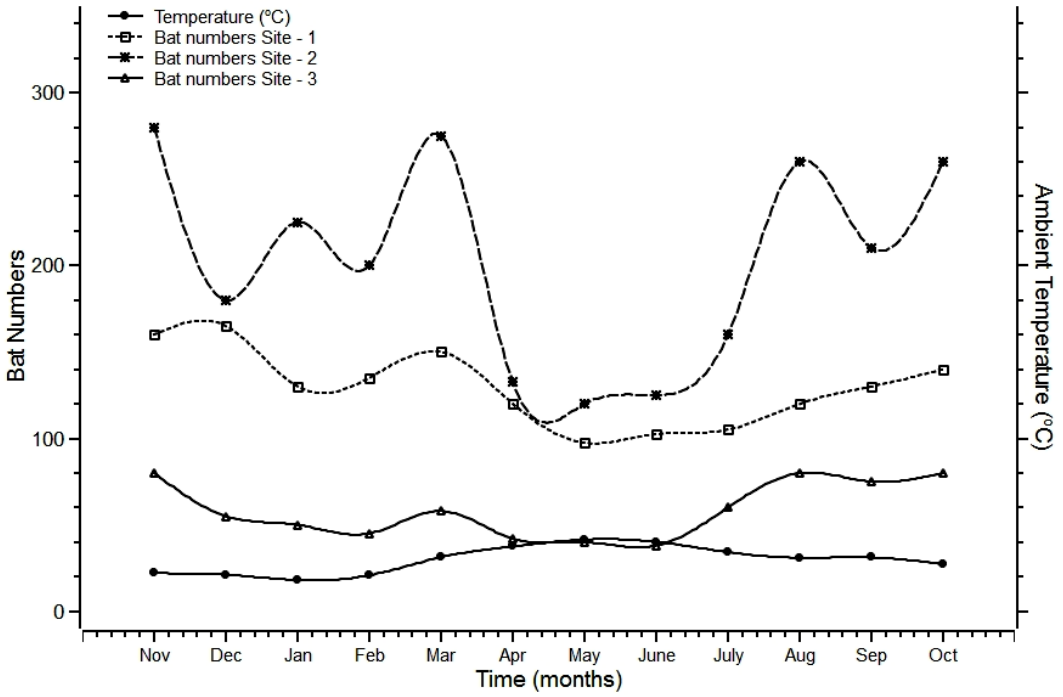


Figure 3: Seasonal fluctuation in bat population along with ambient temperature from November 2010 to October 2011. Site 2 always supported higher numbers followed by site 1 and site 3. During the hotter months the local number of roosting bats declined.

Discussion

Habitat occupancy and maintenance by *Pteropus* requires a variety of geographic, physical and ecological characteristics which control their behaviour and population dynamics (Palmer & Woinarski, 1999; Pierson & Rainey, 1992). *Pteropus* species often choose trees which provide better protection against unfavourable environment and updrafts for easier flight (Pierson & Rainey, 1992; Richmond *et al*., 1998). During the present investigation *P. giganteus* was found to occupy different types of roosting trees at the three study sites, which reflect their flexibility to occupy diverse habit conditions. During the present investigation, *P. giganteus* was found to roost in open tree branches, as has been found by other researchers (Pierson & Rainey, 1992). Unlike *P. giganteus*, taxa from other parts of the Old World which make seasonal migrations in search of food sources (Eby, 1991; Richards, 1990), the three populations in this study did not migrate seasonally in search of food. Since there were no abrupt changes in the population size of *Pteropus* in the present study it could be concluded that they did not undertake any long distance migration during the present study. However, the population fluctuation pattern does suggest that there must be some local movements. Actually, some local movements were observed during the present study but populations tended to be year round residents. Fragmented forest patches covering about 15 km^2 area still remain surrounding Study Site 1. During the hotter months some members of the *P. giganteus* populations were reported by the villagers to take shelter in this area but none could be detected. Perhaps some fraction of the bat populations used temporary shelters to avoid the excessive ambient temperature and returned to their original roosting sites with the reduction in ambient temperature. The roosting ecology of bats is complex, with interactions of physiological, morphological and behavioural responses, which influence the survival, reproduction and distribution of bats (Bell *et al*., 1986; Kunz 1982). In the present study, ambient temperature was the main controlling factor which most intrinsically influenced the roosting pattern and abundance of bat populations. We found that Site 2 supported more bats than the other two sites. Steady numbers of bats at this site were presumably maintained by means of a balance between natality and mortality unlike the other two sites. According to the older residents of villagers living near the three roost sites, the *P. giganteus* camps have been in existence for over a century. These individuals reported that the number of roosting bats has decreased

consistently over the years due to cutting of roosting trees for road expansion and occasional hunting by outsider nomads for meat and traditional medicines. Anthropogenic disturbances around the globe have been reported to exert negative influence on roosting flying foxes and most often the irreversible consequences have been reported as their numbers decrease (Fujita & Tuttle, 1991; Mildenstein, 2005; Mistry, 1995) which corroborates well with the present findings. However, at these three sites these animals are treated as sacred and protected by villagers (Dey & Chattopadhyay, 2011). Most of the villagers show caring attitudes towards this species and there are no apparent conflicts between human and bats, which in turn has allowed this species to maintain their century old habitat.

Non–anthropogenic causes like storm and severe drought were reported by the villagers to exert negative influence on this species. The ambient temperature during the present study often crossed the survival limits during the hotter months and apparently resulted in mass death of bats. In our study, carcasses were found during the hotter months hanging from the tree branches and on the ground. However, carcasses fallen on the ground were swiftly removed by scavenging mammals and birds. The villagers also reported that fresh carcasses were occasionally collected by outsider nomads for meat and traditional medicines. This occurrence of mass death is repeated every year during the hotter months at each study site and has been observed by the villagers for quite some time now. Unfortunately no data on mortality rates due to temperature rise is presently available and hence needs further investigation.

Ecological importance of fruit bats is immense and the critical role played by them as pollinators and seed dispersers is now well established (Banack, 1998; Fleming & Estrada, 1996; Godinez–Alvarez *et al*., 2002; Shilton *et al*., 1999). At least 300 plant species in the Old World rely on fruit bats for their propagation (Fujita & Tuttle, 1991; Marshall, 1983). Unfortunately *Pteropus giganteus* is listed as vermin under Schedule V of the Indian Wildlife (Protection) Act and is one of the most persecuted fruit bats in south Asia. Ali (2010) has reported a 48% decline in *Pteropus giganteus* population from a single roosting site in Assam, India during his 10 years of study from 2001 to 2010 chiefly due to anthropogenic activities. It is high time to reassess the values and services of this species in terms of recent findings. More intensive studies in this regard must be undertaken to protect and conserve the dwindling populations of Indian flying fox.

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