Distribution and conservation issues of Indian flying fox, *Pteropus giganteus* in Uttar Pradesh

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Introduction

The mammalian order Chiroptera consists about 1,232 species which represents a quarter of the total 5,487 mammal species of the world (Schipper et al. 2008; Simmons 2010; Kunz et al. 2011). India has a rich diversity of bat fauna comprising approximately 119 species of bats, out of which 14 species are fruit-eating or megachiropteran (Pteropodidae) belongs to 8 genus and the remaining are insect-eating or microchiropteran bats (Bates and Harrison 1997). The megachiropteran bats are the Old World fruit bats relying on their visual acuity (Telling et al. 2000; Jones et al. 2002) and olfactory system to navigate and forage (Safi and Dechmann 2005).

The Indian flying fox, *Pteropus giganteus*, one of the largest fruit bats belongs to the family Pteropodidae is widely distributed and known as largest flying mammal in India. The IUCN red list of threatened species 2011 categorized this species as least concern (LC version - 3.1). *Pteropus giganteus* is generally a colonial species and roost in large trees often in area with topographic features that offer protection from strong winds, assist in thermoregulation and provide access to updrafts for easier flight (Cheke and Dahl 1981; Pierson and Rainey 1992; Richmond *et al.* 1998). They have a face that resembles that a fox, to some extent and also have good eye sight which helps in finding the food. The colonies were generally located in close association with human beings and observed in cities and villages. Ficus trees are the most favoured roosting trees, however they also known to roost on *Eucalyptus globulus, Mangifera indica* and *Tamarindus indica* (Vendan 2003). At dusk flying-foxes leave the roost to forage upon flower, nectar and fruit of trees in agroforest plantation as well as in primary and secondary forest (Pierson *et al.* 1996). These bats are economically important to our society. They benefit us pollination and seed dispersal and play crucial role in the maintenance of forest ecosystems worldwide (Wiles and Fujita 1992). The status and geographical limits of this taxon are still uncertain. This study has undertaken to find out the status and distribution of *P. giganteus* in state Uttar Pradesh.

Study area

The study was conducted in different districts of Uttar Pradesh (Fig. 1), namely Tajpur, Tanda, Ambedkar Nagar (26°33'04.87"N, 82°39'20.61"E), Nasrullahpur, Tanda, Ambedkar Nagar (26°32' 53.11"N, 82°33'37.91"E), Mohanpur, Akbarpur, Ambedkar Nagar (26°26'57.80"N, 82°43'48.37"E), Chaturpatti, Gosaiganj, Ambedkar Nagar (26°28' 07.85"N, 82°41'38.49"E), Utharu, Gosaiganj, Ambedkar Nagar (26°28'07.85"N, 82°41'38.49"E), Lodhipur, Akbarpur, Ambedkar Nagar (26°29' 50.44"N, 82°33'48.14"E), Ishwarpur, Azamgargh (26° 0'26.61"N, 83° 47'49.74"E), Devipatan Temple, Tulsipur, Balrampur (27°32'13.06"N, 82°44' .45.28"E), Durgapur, Barabanki (27°06'12.92"N, 81°27'40.87"E), Basauri, Ram Sanehighat, Barabanki (26°48'21.49"N, 81°31'42.60"E), Lar Town, Deoria (26°12'05.04"N, 83°58'06.92"E), Khapra Deeh, Pandey ka pura, Tarun, Faizabad (26°47'09.71"N, 82°08'13.86"E), Bhada, Tarun, Faizabad (26°46'48.77"N, 82°08'34.56"E), Vankhandeshwar Temple, Sirshaganj, Firozabad (27°03'21.31"N, 78°40'50.62"E), Nawabganj, Gonda (26°52′00.00″N, 82°08′36.89″E),

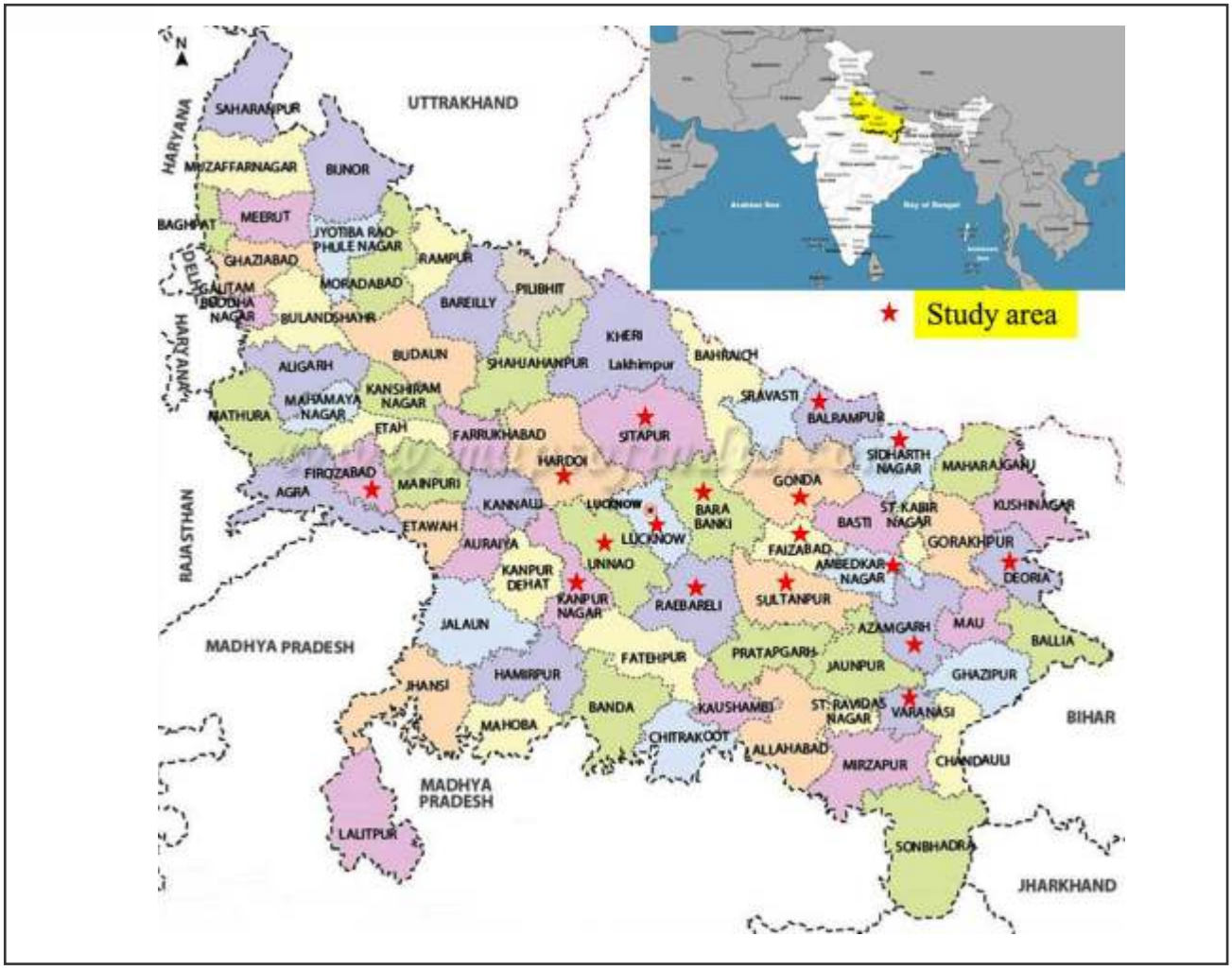

Fig. 1. Map of the study area

Kashipur, Hardoi (27°23′24.35″N, 80°07′17.27″E), R. A. Quidwai Inter College, Dharmasala Road, Hardoi (27°23′08.89″N, 80°07′37.55″E), Company bag garden, Kanpur (26°29'26.99"N, 80°18'58.30"E), Amova, Piparsand, Lucknow (26°45'00.09"N, 80°45'59.37"E), Behind Shitala Devi Temple, Kakori, Lucknow (26°51'46.88"N, 80°47'13.90"E), Utrawa, Mohanlal ganj, Lucknow (26°41'22.31"N, 80°59'03.64"E), Daudapur, Sultanpur road, Lucknow (26°47'20.46"N, 81°01' 28.08"E), North Railway garden, Mohanlalganj, Lucknow (26°41'10.59"N, 80°59'1.63"E), Shivpur, Raibareilly (26°13'59.84"N, 81°14'00.26"E), Sadhunagar, Siddharth Nagar (27°16'16.40"N, 82°49'28.04"E), Bhitiya, Sadhunagar, Sidharth Nagar (27°16'16.40"N, 82°49'28.04"E), Koiri, Sidharth Nagar (27°24'00.33"N, 82°57'14.11"E), Ganeshpur, Sidharth Nagar (27°16'14.86"N, 82°49'30.03"E), Kachehri, Sitapur (27°33'52.61"N, 80°41'13.56"E), Diyara Bazar, Diyra, Sultanpur (26°13'31.67"N, 82°17'03.07"E), Bahwa, Kalukheda, Unnao (26°33'17.73"N, 80°54'28.75"E), Shikarpur, Unnao (26°32'54.09"N, 80°29'09.09"E) and Near Sarnath, Varanasi (25°22'51.81"N, 83°01'17.14"E).

Materials and methods

The study was carried out between August 2009 and March 2014 to locate the distribution of *Pteropus giganteus* in Uttar Pradesh. The roost search was conducted during day hours. The tree roost characteristics such as duration of occupancy,

circumference, diameter at breast height (DBH), height of the roost, total number of roost trees, colony size, roost location (like near forest, road, bridge, residence, ponds, river etc.) and geographical location were recorded. The colony size was assessed through direct count using binocular and photographic methods (Tuttle 1979).

Results

Pteropus giganteus is a largest fruit bat and largest flying mammal in India. The snout is long and hairy. *P. giganteus* has well developed nostril and long pointed black ears. The pelage is chestnut brown on the crown of the head and relatively darker around eyes (Fig. 2). The average forearm length was 150.66 ± 3.08 mm. The morphological measurements of four bats died due to electrical shock were collected and given in Table 1. *Pteropus giganteus* camps were observed in the present investigation found in large diurnal roosts which comprise several hundreds of individuals usually located in well exposed larger trees such as *Azadirachta indica* (Neem), *Bambusa balcooa* (Bamboo), *Dalbergia sissoo* (Shisham), *Ficus bengalensis* (Baniyan), *F. glomerata* (Cluster Fig), *F. racemosa* (Gular), *F. religiosa* (Peepal), *Holoptelea integrifolia* (Chilbil), *Limonia acidissima* (Kaitha), *Madhuca indica* (Mahua), *Mangifera indica* (Mango), *Syzyium cumini* (Jamun), *Tamarindus indica* (Tamarind) and *Vachellia nilotica* (Babool). The colonies of *P. giganteus* generally located nearby water bodies, close association with human beings and in cities and villages.

Pteropus giganteus leaves the roost site about sunset and returns to its day roost at dawn. It commonly roosts with its head downward and wrapped wings around its body. During warm hours of the day individuals often cool themselves by fanning their wings. *Pteropus giganteus* roosts in trees and usually associated with forest fragments or linear patches of vegetation alongside the water bodies.

A total of 8447 individuals were recorded in 33 colonies of *P. giganteus*. The colony size ranged from 50 to 1650 individuals of *P. giganteus*. Out of 33 colonies, sum of 15 colonies were located nearby water bodies and rest of them located closest to agricultural field, road side and residential area. *Pteropus giganteus* selected larger and taller trees such as *F. bengalensis, S. cumini, M. indica, F. religiosa, D. sisoo, B. balcooa, E. tereticornis, T. indica* and *M. indica*.

The DBH of roost trees ranged from 14.15 – 185.93 cm. *Pteropus giganteus* preferred to roost in

Table 1. Morphological measurements of Pteropus giganteus (n = 4)

S. No.	Morphological parameters (mm)	Mean ± SD
1	Head and body length	209.00 ± 08.08
2	Head length	67.74 ± 02.31
3	Hind-foot length	40.17 ± 0.78
4	Tibia length	69.65 ± 04.72
5	Forearm length	150.66 ± 03.08
6	Ear length	35.10 ± 01.30
7	Ear width	16.74 ± 02.30
8	Wing span	962.50 ± 66.02
9	Thumb length	41.55 ± 08.46
10	Length of second metacarpal	83.77 ± 17.59
11	Length of third metacarpal	100.58 ± 06.21
12	First phalanx of the third metacarpal	76.62 ± 04.51
13	Second phalanx of the third metacarpal	103.55 ± 06.57
14	Fourth metacarpal	99.30 ± 07.55
15	First phalanx of the fourth metacarpal	59.25 ± 03.90
16	Second phalanx of fourth metacarpal	58.56 ± 04.53
17	Fifth metacarpal	104.23 ± 07.85
18	First phalanx of the fifth metacarpal	46.32 ± 02.65
19	Second phalanx of fifth metacarpal	44.66 ± 03.68
20	Body weight (g)	545.00 ± 40.41
21	Maxillary tooth-row	25.50 ± 0.52
22	Mandibular tooth-row	26.68 ± 0.42

* Data collected from dead male bats, female data not available

Table 2. Roost trees and roost characteristics of *Pteropus giganteus*.

S. No	Name of Tree	Circumference (cm)	DBH (cm)	Height of Roost Trees (m)	Height of Roost (m)	No. of colonies	No. of Roost Trees	No. of bats per tree
1	*Azadirachta indica* (Neem)	300.99 ± 77.23	95.80 ± 24.58	08.33 ±0.52	06.83 ± .75	03	06	29.50 ±34.01
2	*Bambusa balcooa* (Bamboo)	44.45 ± 5.12	14.15 ± 1.63	13.70 ± 2.45	11.50 ± 3.02	05	16	19.10 ± 11.15
3	*Dalbergia sissoo* (Shisham)	188.98 ± 47.48	60.15 ± 15.11	09.80 ± 2.25	8.50 ± 2.22	08	10	18.40 ± 13.01
4	*Eucolyptus tereticornis* (Eucolyptus)	82.02 ± 25.32	26.11 ± 8.06	15.98 ± 1.43	13.83 ± 1.48	13	119	25.93 ± 14.79
5	*Ficus bengalensis* (Baniyan)	477.52 ± 68.08	151.98 ± 21.67	11.04 ± 1.96	9.02 ± 1.93	14	22	61.63 ± 35.55
6	*Ficus glomerata* (Cluster Fig)	584.20	185.93	12	10	01	01	56
7	*Ficus racemosa* (Gular)	340.92 ± 104	108.50 ± 33.26	12.44 ± 1.33	10.67 ± 1.22	03	09	18.89 ± 14.80
8	*Ficus religiosa* (Peepal)	442.88 ± 86.30	140.95 ± 27.46	11.27 ± 1.55	9.18 ± 1.72	07	11	52.18 ± 40.14
9	*Holoptelea integrifolia* (Chilbil)	399.14 ± 39.77	127.03 ± 12.65	10.14 ± 0.69	8.14 ± .69	02	07	33.57 ± 16.36
10	*Limonia acidissima* (Kaitha)	224.37 ± 12.00	71.41 ± 3.82	08.33 ± 0.57	8.00 ± 0.12	01	03	50.00±25.00
11	*Madhuca indica* (Mahua)	411.48 ± 35.50	130.96 ± 11.30	11.75 ± 1.75	9.87 ± 1.88	06	08	29.75 ± 18.52
12	*Mangifera indica* (Mango)	182.30 ± 63.28	58.02 ± 19.82	08.45 ± 1.21	7.12 ± 1.10	14	44	28.52±22.82
13	*Syzyium cumini* (Jamun)	328.08 ± 55.84	104.42 ± 17.77	11 ± 2.19	9.25 ± 2.04	03	06	36.17 ± 19.14
14	*Tamarindus indica* (Tamarind)	385.06 ± 57.51	122.55 ± 18.30	11.40 ± 2.40	9.20 ± 1.64	05	05	60.20 ± 43.79
15	*Vachellia nilotica* (Babool)	429.26 ± 46.35	136.62 ± 14.75	08 ± 0.50	7.00 ± .12	01	03	40.33 ± 18.44

Note : Values are given as mean ± SD

larger *Ficus* trees compared to other tree species. Similarly, a maximum number of bats roosted in Ficus trees (Table 2). There was a positive correlation between population size and DBH of roost trees ($r = 0.634$, $n = 86$, $P < 0.001$), however the height of roost trees did not influence the population size ($r = -0.197$, $n = 86$, $P > 0.05$).

The distribution of *P. giganteus* was widespread in Ambedkar Nagar district. A total of six colonies of *P. giganteus* were observed in Ambedkar Nagar. The colonies were observed adjacent to water bodies and amid of agricultural field. At Ambedkar Nagar, *P. giganteus* occupied the larger trees such as *F. bengalensis, F. racemosa, S. cumini, M. indica, D. sissoo, B. balcooa, M. indica* (Mahua) and *E. tereticornis* (Fig. 3 & 4). Similar to Ambedkar Nagar, a large number of colonies were observed at Lucknow, Barabanki, Faizabad, Hardoi, Kanpur, Siddharth Nagar and Unnao districts (Fig. 5, 6, 7 & 8).

The highest population (1650 individuals) was observed at Amova, Piparsand, Lucknow while the lowest population observed at Utharu. During winter, the colony occupied the larger trees such as

Fig. 2. Indian flying fox, *Pteropus giganteus* (male)

Fig. 3. A colony of *Pteropus giganteus* roost on Ficus bengalensis trees at Lodhipur, Ambedkar Nagar

Fig. 4. Fig. 4. A colony of Pteropus giganteus roosts on *Mangifer indica* trees at Tajpur, Tanda, Ambedkar Nagar.

Fig. 5. A colony of *Pteropus giganteus* roost on *Limonia acidissima* tree at Pipersand, Lucknow

Fig. 6. A colony of Pteropus giganteus roosts on *Eucalyptus* sp. trees at Mohanpur, Faizabad

Fig. 7. A colony of *Pteropus giganteus* roosts on *Eucolyptus tereticornis* Behind Shitala Devi Temple, Kakori, Lucknow

Fig. 8. A colony of *Pteropus giganteus* roosts on *Holoptelea integrifolia* trees at Company bag garden, Kanpur

F. religiosa, M. indica, M. indica (mahua), *B. balcooa* and *E. tereticornis.*

A colony of *P. giganteus* observed at Shitala Devi Temple, Kakori shared the roost trees with snake bird. There were three ponds adjacent to this colony. As reported by the villagers, this colony is protected by the local residents, however sporadic hunting taking place at times.

During day hours, individuals of *P. giganteus* actively involved on squabbling, cleaning and scratching with claws, fighting for better roosting positions. At times, defecation was also observed during day hours. The wing fanning during summer and basking with stretched wings during winter were commonly observed. Reproductive behaviours such as pair bonding and mounting were observed between August and October, while infants were born from February to April.

The threats include netting, shooting for bush meat were recorded rarely. The major threats to *P. giganteus* were destruction of roosting habitats by tree felling. In addition, bat conservation programs were conducted at roosting sites of *P. giganteus* to create awareness about bats among public.

Discussion and conclusion

The Indian flying fox, *Pteropus giganteus* widely distributed throughout India. The current study reveals the occurrence of high population of *P. giganteus* in Uttar Pradesh. The distribution of *P. giganteus* was already reported in Philibhit (Wroughton 1914); Lucknow and Varansi (Sinha 1980); Allahabad (Bhatnagar and Srivastava 1974). However, the results of current study revealed the wide distribution of *P. giganteus* in Uttar Pradesh. The results showed that *P. giganteus* selected their roost trees in well exposed larger trees such as A. indica, *B. balcooa, D. sissoo, E. tereticornis, F. bengalensis, F. glomerata, F. racemosa, F. religiosa, H. integrifolia, L. acidissima, M. indica* (Mahua), *M. indica, S. cumini,* and *T. indica*. The possible reasons for selection of above roost trees due to long lasting and stable nature. Further, the tall trees in well exposed areas may support their flights during take-off and landing.

The behaviour such as wing fanning during summer and wing wrapping during winter associated with thermoregulation. The wide distribution and high colony size of *P. giganteus* show that the state Uttar Pradesh has suitable habitat for its survival. Further, the location of majority of colonies nearby water bodies suggests that the bats select their day roost to avoid high temperature at day hours during summer. The positive correlation between colony size and DBH of roost trees clearly suggests that the bats are selecting larger trees while many other trees are available. Fruit bats play a pivotal role as pollinators and seed dispersers for a diverse array of plants which were also reported earlier (Fleming and Estrada 1996; Banack 1998; Shilton et al. 1999;

Godinez-Alvarez *et al*. 2002).

Hunting of *P. giganteus* was not completely stopped in the study area as there were rare observations on netting, shooting for bush meat. However, the habitat destruction by tree felling was a major threat to *P. giganteus*. To ensure the survival of this species, roost habitat must be protected. The protection of roost habitat alone is insufficient to ensure the survival of this species. Further investigations on seasonal distribution, maternity roost and feeding sites are essential for survival of the species. Thus, it is critically important to preserve the existing roosting habitats of *P. giganteus* in Uttar Pradesh, because bats play vital roles in balancing the ecosystem, seed dispersal and regeneration of forests.

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