Chapter III

POPULATION DYNAMICS OF THE INDIAN FLYING FOX, *PTEROPUS GIGANTEUS*

INTRODUCTION

Indian flying fox, *Pteropus giganteus* is a sacred species in India (Marimuthu, 1988) and most persecuted bats in South Asia (Singaravelan et al., 2009; Srinivasulu and Srinivasulu, 2012). Generally, *Pteropus* prefer sustained roost and it might be a reason for the selection of large and long living trees (Granek, 2002). Though, several bat species have reported that they made roost in different part of the plants such as *Cynopterus sphinx* and *Platyrhinus helleri* chews palm leaves and make tent like roost (Storz et al., 2000), *Chalinolobus tuberculatus* in tree trunk (Sedgeley and O'Donnell, 1999) but flying foxes are an exclusive fruit bats, make open roost on foliage. Therefore, flying foxes have directly faced all climatic changes. However, the ever changing pattern of climate influence flying foxes population and obviously, it hampered ecosystem services (Kremen et al., 2007; Welbergen et al., 2008).

In the natural condition, bats are categorically known as long living and slow reproducing mammal live in various geographical locations except in few islands and Antarctic regions (Barclay et al., 2004; Srinivasulu et al., 2010). Presumably, slow maturation caused a high level of threat and mortality, therefore, they considered as one of the most threatened group in mammalian taxa (Racey and Entwistle, 2000; Wilkinson and South, 2002).
Temperature plays a significant role in the population ecology of animals and phenology of plants (Walther et al., 2002). Therefore, animals adjust their behaviour, migration, and reproduction with reference to temperature (Winkler et al., 2014). In the natural history of bats, a couple of study have demonstrated that low temperature caused delay in sexual maturity and prolonged gestation while high temperature induces improper fetus development and even death of bats (Racey and Speakman, 1987; Lewis, 1993). It is a well elaborated concept in the behavioural ecology that temperature is a key factor which determines reproductive success in bats. In general, bats are resilient with little changes in weather and they alter life history trade accordingly (Frick et al., 2010). However, slight change in temperature may not entertain much more by bats and as usual, they adjust diurnal, emergence and foraging activities while longer exposure of ambient temperature caused seasonal roost displacement and even fragile death in flying foxes (Welbergen et al., 2008). Therefore, most of the temperate bats give birth to young ones and rearing them in spring to early summer. However, neonates access a wide range of food diversity and high level of survival and fecundity because of congenial environment. During pregnancy and lactation, female needs to be gain plentiful water and food stuff for proper fetus development and milk production. Therefore, lactating females maintain maternal roost for the survival of neonates (Racey and Speakman, 1987; Heideman, 2000). In temperate bats, reproduction during hot periods or water scanty are not viable for offspring hence, such pregnant female makes behavioural as well as physiological adaptation to spent more body energy in reproduction and parental investment. Therefore, they are facing a great level of extinction risk (Isaac, 2009).
Currently, there are a number of natural as well as anthropogenic factors playing major role in the population reduction in bats. However, a little is known about the influence of these variables at colony level but some other factors such as resource availability (Arlettaz et al., 2017), hunting (Struebig et al., 2007; Jenkins and Racey, 2008), natural predators (Welch and Leppanen, 2017), urbanization (Jung and Kalko, 2011), roost harassment (McClelland, 2009), and climate variability is collectively determines roost persistency (Rebelo et al., 2010) and fidelity of bats (Lewis, 1995; Arlettaz et al., 2001).

Since few decades back, the rate of habitat destruction and hunting exaggerated exponentially. Therefore, the population of *P. giganteus* declined dramatically (Venkatesan, 2007; Ali, 2010). Ali (2010) reported that around 48% of the population has been decreased due to anthropogenic activities nearer to the roost site in Assam. As a result, *P. giganteus* become threatened and listed as Least Concerned species (Singaravelan et al., 2009). As the recent data indicated that the population dynamics of the most flying foxes are entirely faraway from the scientific investigation. Contextually, all together caused data deficient in the population ecology of flying foxes. In order to significant conservation initiatives of flying foxes, long term population studies need to be implemented at colony level for accessing the population trends. Therefore, the recent trend of scientific investigation particularly population aspects of flying foxes have become more venerable for sustain management (McConkey and Drake, 2006).

Although bats have significant importance in various ecological process and constitutes around 20% of mammalian fauna (Mickleburgh et al., 2002; Schipper et al., 2008) but the availability of information on demography, age structure, sex ratio and
survivability of most bats are largely unknown (Purohit and Vyas, 2006). However, a number of researcher who solely carried investigation on the population ecology of bats such as Tadarida brasiliensis (Romano et al., 1999), Myotis lucifugus (Frick et al., 2010), Eptesicus fuscus (O'shea et al., 2011), Eidolon helvum (Hayman et al., 2012). The hypothesis of this study began with the fundamental question on the population ecology of Pteropus giganteus i.e. Does the population of P. giganteus fluctuated and why its need to be investigated ?.. Though, these are quite a common question but when it falls with wild and nocturnal species which is staying in inaccessible areas. It was absolutely challenging to observe the population periodically and estimate the natural dynamism of P. giganteus. Keeping all the challenges collectively, the proposed study was carried out to investigate the population dynamics of Indian flying fox, Pteropus giganteus.

MATERIALS AND METHODS

A maternal roost of Pteropus giganteus at Mohanlal Ganj, Lucknow, Uttar Pradesh (26°40'57.56"N; 80°59'1.49"E) was extensively studied between Jan 2014 and Dec 2016. In the study site, P. giganteus were predominated on Eucalyptus trees while few other trees such as Azadirachta indica, Dalbergia sissoo and Ficus religiosa was observed as a seasonal roost. A visual count method was used for population estimation of P. giganteus while branch estimation, binocular and photography was extensively applied in inaccessible roost. During the study, the population of neonates, death, immigrant and emigrant was recorded. In addition, the physical parameters such as temperature (°C) and humidity (%) was measured using thermo-hygrometer in each consecutive day of the observation. Further, to ascertain the effect of temperature and humidity on the population of Pteropus giganteus, paired t-test was applied.
RESULTS

It was observed that the population of *Pteropus giganteus* fluctuated over the study period. The colony size of *P. giganteus* increased exponentially in reproductive season due to mass aggregation of immigrants (Aug – Nov, 449.8 ± 44.6 SD) and the most abundant population was recorded in the month of September (*n* = 1495, Figure 1). The individuals of adjacent roost sites such as Miranpur and Achelikhera were aggregated for availing mating opportunities. Thus, the population size of Miranpur and Achelikhera decreased steeply while Mohanlal Ganj increased during the reproductive season of *P. giganteus*. Due to the abundance of population size, the individuals roosting over the grove and colony was observed as noisy. The dispersal of migrant individuals during non-reproductive season caused dramatic changes in the population size of *P. giganteus* in May and June (220.3 ± 108.4 SD) while it stable in winter season (Nov, Dec, and Jan, 447.5 ± 90.2, Figure 3.1).

Other than neonates, the congenial roost and large grove attract immigrants to stay for avail reproductive opportunities. Thus, it might be a reason for population abundance in March and April (414 ± 138 SD). The dispersal of emigrant started with the end of breeding season hence, the population size of *P. giganteus* decrease drastically in summer season particularly in June (*n* = 211). The highest ambient temperature was recorded during June (42.4 °C) while lowest in January (4.9 °C) but the colony size decreases with increasing temperature and remains stable during low temperature due to pregnancy and harsh weather.
Figure 3.1. Population dynamics of the Indian flying fox, *Pteropus giganteus*.

*Pteropus giganteus* shifted roost from the canopy to trunk region and leafy area in the roost trees and also made a well shape cluster due to heat waves (Plate 3.1). However, it was also observed that a number of bats died due to high temperature and it was recorded from various roost sites of the study area (41.6 ± 36.6 SD). Due to heat shock, a huge number of *P. giganteus* died from the single roost in Kanpur (*n* = 84). Thus, it shows that temperature has a significant influence on the population of *P. giganteus* (*t* = 5.710, *p* < 0.001). The dead individuals were recorded from the ground (Plate 3.2) as well as different part of roost trees (Plate 3.3).
In addition, few other death cases were recorded during winter season particularly in foggy periods (Dec – Jan). Due to the long foraging movement, *Pteropus giganteus* accidently contact in eclectic wire and a number of dead bats shock was recorded in Ambedkar Nagar (*n* = 4), Bareilly (*n* = 2), Faizabad (*n* = 7), Lucknow (*n* = 9, Plate 3.4), Shajahanpur (*n* = 2) and Sitapur districts (*n* = 2, Plate 3.5). Though humidity was highly varied over the study period but it facilitates a congenial environment for social interaction during reproductive season (Aug – Nov, 67.7 ± 16.1%), fetus development and parturition (Nov – Mar, 69.9 ± 9.2%). However, it also plays crucial role clustering of *P. giganteus* during summer season (48.3 ± 8.7%, *t* = 5.028, *p* > 0.001, Figure 3.3).
Plate 3.1 A well shape cluster of *Pteropus giganteus* during summer season.

Plate 3.2. A dead individual of *Pteropus giganteus* at roost site.
Plate 3.3. *Pteropus giganteus* died due to heat shock at the maternal roost.

Plate 3.4. *Pteropus giganteus* died due to electric shock at Vrindavan Yogna, Lucknow.
Plate 3.5. A died individual of *Pteropus giganteus* at Sitapur district.

**Figure 3.3.** Effect of humidity on the population of *Pteropus giganteus*.

The parturition of *Pteropus giganteus* was observed in February, March and April. It was observed that *P. giganteus* gives single pup in a breeding cycle. The population of neonates was 39.0 ± 7.5 (SD). However, infants were exclusively cared by
mother for 30 days, until they can roost and fly independently. It was also noticed that lactating mothers generally made solitary roost either at the peripheral branches or trunk region of the roost trees. The lactating females were actively engaged in neonate grooming and nourishing (Plate 3.6).

Plate 3.6. Mother carrying pup at the roost tree.
Plate 3.7. A newly parturient female along with pup at the maternal roost.
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**DISCUSSION**

The present study address the population dynamics of Indian flying fox, *Pteropus giganteus*. The individuals of *P. giganteus* exhibited seasonal variation in population during reproductive season. Hence, the population size of *P. giganteus* increased dramatically due to gathering of immigrants possibly male individuals for availing mating opportunities and colony size decreased at the end of mating season due to the dispersal of emigrants. Thus, reproductive season have a significant role in the aggregation and segregation of flying foxes population (Sugita *et al.*, 2009; Mathur *et al.*, 2012; Sugita and Ueda, 2013).

In non-reproductive season, population slightly increased due to the addition of neonates and presence of few immigrants possibly large grove size attract them for roosting along with the residential population of *P. giganteus*. During summer season, camp decreased due to the dispersal of emigrant population. Moreover, temperature also raised in summer season, particularly in May and June. Hence, *P. giganteus* alter roosting position and make a well shape cluster at trunk and leafy area for thermal balance. However, alteration of roosting area during mating and cluster formation due to temperature has widely reported (Ochoa-Acuña and Kunz, 1999; Sugita *et al.*, 2009; Sugita and Ueda, 2013). The ambient temperature caused mortality of sub-adult and adults of *P. giganteus* hence population size decreases with increasing temperature as it was reported previously in *Pteropus alecto* and *P. poliocephalus* (Welbergen *et al.*, 2008). The study area has ample of roosting wealth and climatic extreme. The presence of water bodies near to the roost provide humid environment and also helps in thermal balance to the bats and it enhances survivability and reproductive fitness of bats (McCain,
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2007; Sherwin *et al.*, 2013). *Pteropus giganteus* are adapted to travel long foraging distance within the short span but due to invisibility in foggy nights, they accidentally get trapped into electric wire and a number of dead bats were recorded. However, the accidental death of *P. giganteus* due to electric shock has widely reported in various studies (Chakravarthy and Girish, 2003; Ali, 2010).

The individuals of *Pteropus giganteus* gives birth in the spring season. The spring season provides food abundance and also minimizes foraging movement, maximize resource utilization and it enhances parental investment (Welbergen, 2006; McCain, 2007). In initial weeks of birth, neonates attached with mother and mother generally prefers solitary roost due to intraspecific conflict. The neonates are cared by mother until they roost independently. A study suggested that the neonate of *P. alecto* were closely attached with mother until they can fly and hang upside down freely (Markus and Blackshaw, 2002). Thus, this study shows that the population of *P. giganteus* fluctuated over the study period. The congenial temperature and humid environment during parturition support neonatal survivability.