Annals of Plant Sciences
ISSN: 2287-688X
OPEN ACCESS
www.annalsofplantsciences.com

Original Research Article

Foraging Behaviour of Indian Flying Fox *P. giganteus* in Kerala

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Received for publication: September 05, 2014; **Accepted:** October 17, 2014.

Abstract: Over one year period, field study was conducted for the identification of food plants and seed dispersal of *Pteropus giganteus* by direct observations or indirectly by the analysis of eject found on ground. Observation were made on seven colonies of day roost in undisturbed areas, amongst which six of them were in sacred grooves one in the protected area. Over 22 different plant seeds were collected from the ejected materials as chewed fruits, fresh seeds or faecal materials. The result indicates that *Pteropus* is playing a vital role as a seed disperser in plants like *Anacardium occidentale, Areca catechu, Manilkara achras, Mangifera indica* and *Psidium gujava* which are highly demanding plants in the market. The study concluded the mutual relationship between plants and fruit bat, flying foxes depends plants for food and roost while plants need bat as disperser and pollinator.

Key Words: *P. giganteus*, Kerala, field study

Introduction

Feeding behaviour of bats was influenced by fruit traits and it varies across bat species. Feeding behaviour of fruit bat was greatly influenced by fruit quality, especially, the fruit hardness. It may also be expected to vary significantly among bats and to be an important aspect of their resource partitioning strategies (Dumont 1999; Aguirre *et al.,* 2002). Fruit bats have an unusual mode of feeding in which they consume the fruits in small bites, pressing out and swallowing the juice and spitting out rind as compact pellets (Morrison 1980). Megabats may or may not remove fruits from a tree and they typically cling on to flowers and fruits, while lapping up nectar or ingesting soft pulp and fruit juices (Fleming 1982). They may consume large fruits *in situ* (Van der Pijl 1957). However, smaller fruits are usually carried away from the trees to special feeding roosts for consumption (Elangovan *et al.,* 1999). The strategy between bat species in their treatment on the same fruits is influenced by bat size. A larger *Pteropus* sp. can fly off with a whole mango while a smaller *Cynopterus* sp. simply bites off pieces of the flesh *in situ* (Corlett 1998). There are relatively few data concerning the feeding behaviour of the Indian flying fox *Pteropus giganteus* and the already known information on this species is mostly centered on foraging trees (McCann 1934, 1941) and behaviours they exhibit at day roosts (Neuweiler 1969).

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The treatment on smaller fruits again depends on bat size, smaller bats usually pluck a fruit, fly away to nearby feeding roosts (20-200m away from the fruiting tree) where they process the fruits (Marshall 1983; Phua and Corlett 1989) such feeding roosts are known as night roost. However, larger bat species seem more likely to process fruits in the fruiting tree itself. At feeding areas, pteropodids usually defend small territories of fruits or flowers in the canopy (Neuweiler 1969; Gould 1977; Richards 1990; Banack 1998; Brooke 2001). There is little or no report on Indian flying fox *P. giganteus* about the resource defense.

Materials and Methods

The fruits and leaves consumed by *P. giganteus* were collected once in a fortnight in roosting as well as in the foraging areas. The collected fruits and leaves were identified taxonomically and also the discarded parts were recorded. The weight of the fruits carried to the roosting area is also measured using balance. Among the discarded fruits the economically important fruits to the humans were recorded.

The foraging activities of these fruit bats were also monitored in selected trees like *Bassia latifolia*, *Ceiba pentandra* and *Ficus religiosa*. The foraging activities of *P. giganteus* were monitored from 18h to 6h until the returning of the bats from the

foraging trees. These bats were observed using red filtered torchlight since it gives little or no disturbance to the foraging bats. The number of bats visiting a particular tree was counted using mechanical counter. Since the bat spent most time in the foraging tree the number of bats present in the foraging tree for every 30 minutes were recorded. In the foraging tree whether the bat feed the fruits in the same tree or carried the fruits to the neighbouring feeding roosts were monitored. The interspecific and intraspecific interactions of these bats in the foraging trees were also recorded.

Results

Fig trees, plantain field, and guava and sapota orchards surround most of the *P. giganteus* roosting places in Kerala. So they get year round supply of food. These bats consumed fruits, nectar and leaves of about 22 species of plants in the study area (Table 2). The diet of *P. giganteus* consisted predominantly the fruits of fig trees. During the lean period it also consumed the leaves of *Ficus religioa* and *Erythrina indica*. Most of the fruiting trees visited by these bats are tall. However it also feed on fruits from shrubs like *Achras sapota*, *Psidium guajava* and *Musa sp*. which are mostly grown in the orchards. In the tall trees like *F. religiosa*, *F. bengalensis*, *Syzigium cumini* these bats forage in groups of about 10 to 12 individuals. But in shrubby trees it forages solitarily.

The small fruits and flowers such as *F. religiosa*, *F. bengalensis* and *B. latifolifa* it feed the flowers *in situ* i.e. in the same foraging tree itself. But the larger fruits such as *Mangifera indica* and *Psidium guajava*, *P. giganteus* removed these fruits from the parent tree and *ex situ* foraging was observed. Likewise it also removed the fruits of areca nut tree and feed its outer rind and dropped beneath the day roost. These areca nut were collected from day roost and sold in the local market and the bat bitten such fruits are readily brought by local people. Some of the big fruits like *M. indica* and *P. guajava* were partially consumed and dropped beneath the feeding roost. In the fruiting season of 'big bang' trees like *F. religiosa*, *F. bengalensis* and *B. latifolia*, *P. giganteus* arrived to the trees at 19h and remained in the same tree up to 3h consuming the fruits and flowers and rest at the same tree and some bats rest at neighbouring trees after feeding. But in the small trees like *A. sapota* and *P. guajava* these bats came around 20h and spent about 10 to 20 minutes in the tree and removed the fruits and move to the nearby large trees for feeding. Once carried to the fruit it started consuming the fruits bit by bit and chews and spits out the fibrous remains. It uses its forearm to move the fruits to desired direction. It usually consumes entire fruit of ripe mango except the seed but it consumes the outer fleshy part of guava and voids the inner seeded part. After consuming the entire fruit it grooms itself and taken rest for 10 to 15 minutes. The feeding roosts used by these bats are *Albizia lebbek*, *Tamarindus indica*, *Borassus flabelliber*, *Azadirachta indica*, *Syzigium cumini* and *Eucalyptus* spp. Feeding roosts used by these bats located usually next to the foraging tree some time it may located 10 to 200m from the feeding tree. Feeding roosts are individual specific and each bats has its own specific feeding roosts.

Table 1: Foraging plants

S. No	Name of the plants	Parts consumed
1	*Manicra achras*	Fruits
2	*Areca catechu*	Fruits
3	*Artocarpus heterophilus*	Fruits
4	*Bassia latifolia*	Fruits
5	*Borassus flabellifer*	Fruits, (toddy plant)
6	*Carica papaya*	Fruits
7	*Ceiba pentandra*	Nectar
8	*Erythrina indica*	Leaves
9	*Eugenia jambolana*	Fruits
10	*Ficus bengalensis*	Fruits
11	*Ficus religiosa*	Fruits, leaves
12	*Ficus virens*	Fruits
13	*Ficus glomeratus*	Fruits
14	*Mangifera indica*	Fruits
15	*Musa paradisiaca*	Fruits
16	*Parkia biglandulosa*	Nectar
17	*Pithecolobium dulsi*	Fruits
18	*Polyalthia longifolia*	Fruits
19	*Psidium guajava*	Fruits
20	*Tamarindus indicus*	Leaves
21	*Tectona grandis*	Fruits
22	*Terminalia catappa*	Fruits

Discussion

Constantine (1970) reported that the fruit-eating bats could survive only in the areas where fruits are constantly available. Similarly my observation shows that the foraging trees, which give year round, supply of food to these foraging bats surround most of the roosting places of *P. giganteus*. According to Carpenter (1986) and Thomas (1975) the energy cost of flight of pteropodid and phyllostomid bats are 15 times higher than that of resting. So the bat must gather fruits, which give the energy necessary to cover the cost of flight, in addition to

maintenance and breeding effort (Charles-Dominique 1993). My observation showed that it consumed about 22 plant species in the surrounding area to meat out its energy requirements.

Fig fruits dominated the diet consumption of *P. giganteus*. Various species of pteropodid bats have been reported foraging on the fruits of more than 30 fig species in tropical and subtropical Asia, Africa and Australia (Bhat 1994; Fujita and Tuttle 1991; Marshall and McWilliam 1982; Thomas 1984). *P. giganteus* chews the fruits and spits out the fibrous remains along with the seeds in the same tree and sometimes consumes the whole fruit and defecates the seeds. Since food transit time in frugivorous bats are relatively rapid; generally less than 30 minutes (Laska 1990; Tedman and Hall 1985). Several studies have demonstrated that seed germination was either enhanced or unaffected after passage through the digestive tract of bats (Figueiredo and Perin 1995; Fleming and Heithaus 1981; Liberman and Liberman 1986).

P. giganteus was also observed foraging in other trees such as *Bassia latifolia*, *Ceiba pentandra* and *Mangifera indica* during their flowering and fruiting season. This shows that it is an opportunistic feeder. Gardiner (1977) reported that most fruit bats are food generalists rather than food specialists. Similar feeding pattern was observed in the neotropical frugivore *Carollia perspicillata*. It consumes the fruits of about 37 plant species and it concentrates on the fruits of various piper species based on their availability (Fleming 1982).

Since many fruits consumed by bats are rich in soluble carbohydrates and poor in crude protein bats may need to over ingest fruits and dump carbohydrate to meet out their protein requirements (Thomas 1984). However plant visiting bats may supplement their fruit diet with protein rich leaves (Kunz and Diaz 1995; Zortea and Mendes 1993) and insects (Courts 1998). Other than fruits *P. giganteus* also consumed leaves of *F. religiosa* and *Erithrina indica* to supplement their protein requirements. Folivory and frugivory by wedging (extraction of liquid fraction by chewing fruits and leaves and expelling the oral spat) combined with rapid food transit time allows bats to process greater amount of food per unit time. Thus, some bats have evolved a strategy for both maximizing nutrient intake and minimizing gut retention time and thus can be expected to reduce wing loading and energy expenditure while in flight (Kunz and Ingalls 1994). Relative to fruits, which have patchy distributions in space and time (Fleming 1992; Terborgh 1986) leaves of some tropical plant species are ubiquitous and available year round (Ganzhorn 1992). Plant visiting bats that selectively feed on leaves should gain a higher yield of protein per unit of foraging effort, compared to those that feed only on protein poor fruits (Kunz and Diaz 1995). The leaves also contain higher amount of calcium compared to fruits (O' Brien *et al.,* 1998). Early report on low survival rates for Old World fruit bats maintained in captivity were attributed to diets that consisted largely of cultivated fruits. However the diets supplemented with green leaves and multivitamins increases the survival rate of these bats (Rasweiler 1977). So the leaves not only helpful as dietary supplement but also provide other useful nutrients to the foraging pteropodid bats.

The small sized fruits like *F. religiosa* and *F. benghalensis* were eaten in the same tree (*in situ* foraging) by *P. giganteus*. Whereas the larger fruits like *Mangifera indica* were taken away from the foraging tree (*ex situ* foraging) to the feeding roosts by these bats. But in the smaller sympatric fruit bat *C. sphinx* the foraging pattern is entirely vice versa and my observation corroborate that of the foraging pattern of these bats in earlier report (Elangovan *et al.,* 2001). The main reason for the *ex situ* foraging is 1. to reduce feeding interference by other bats and 2. to reduce predation risk (Fleming 1982). Transport of food to a feeding roost is common in small sized bats; *P. giganteus* mostly feed the small sized fruits in the same tree. It is possible that the size of the Pteropus makes them vulnerable to predators waiting at rich patches of food (Fenton *et al.,* 1985).

In the 'big bang' trees like *Bassia latifolia*, *F. benghalensis* and *F. religiosa* groups of *P. giganteus* visited these trees during the flowering season and fighting and vocalization between these bats for acquiring the resource rich patches. This is in consistence with other *Pteropus* spp. (Brooke 2001). We have also observed that there is interspecific fight between the sympatric fruit bat *C. sphinx*. To avoid this fighting and

maximizing the resource use there is a temporal as well as spatial portioning between these bats for the resource use. The larger *P. giganteus* comes late and mainly consume the canopy resources first, whereas smaller *C. sphinx* comes early and concentrate on the understory resources (Singaravelan and Marimuthu 2004; Nathan *et al.,* 2005)

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Source of support: Nil
Conflict of interest: None Declared