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Diet composition of flying foxes in district Kotli, Azad Jammu and Kashmir, Pakistan

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Abstract

The current study investigated the diet composition of Indian flying fox (*Pteropus giganteus*) in district Kotli, Azad Kashmir summer 2018 to 2019. We used the fecal analysis method to document the diet composition of flying foxes and analyzed 107 samples collected from roosting sites. We identified 8 plant species in the diet of flying fox belonging to three families of plants including Moraceae (78.72%), Rosaceae (12.80%), and Myrtaceae (11.34%). We recovered two species belonging to the family Moraceae in the diet of flying fox including *Ficus carica* (46.73%, n=50), *Morus nigra* (29.91%, n=32). Similarly, four species of family Rosaceae were consumed including *Prunus armeniaca* (4.67%, n=5), *Eriobotrya japonica* (3.74%, n=4), *Pyrus pashia* (2.80%, n=3) and *Prunus persica* (0.93%, n=1). Whereas two species of family myrtaceae including *Syzygium Cumini* (9.35%, n=10) *Psidium guajava* (1.87%, n=2) and were consumed by flying fox. Results from this study show that Indian flying fox mainly consumes *Morus nigra* and *Ficus carica carica*. More detailed studies should be conducted to investigate seasonal variation in diet composition of flying foxes, assess local perception towards bats and economic losses faced by local people as a result of flying foxes raiding on the orchids in the study area.

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Introduction

Bats (Mammalia: Chiroptera) are distributed all over the world excluding; Antarctica, the Arctic, and several islands (Hutson and Mickleburgh, 2001). Indian flying foxes (*Pteropus giganteus*) are fruit-eating bats that belong to the order Chiroptera and suborder Megachiroptera (Brunnich, 1782). The order Chiroptera is further divided into two suborders, the Megachiroptera with 186 species and the Microchiroptera with 834 species. Suborder Megachiroptera comprises one family while the suborder Microchiroptera comprises 17 families. Indian flying fox is one of the world's largest bat and it is distributed in India, Sri Lanka, Pakistan, Bangladesh, Nepal, and Burma (Simmons, 2005). In Pakistan, pteropodids consist of three genera and four species which includes the Indian flying fox (*Pteropus giganteus*), the short-nosed fruit bat (*Cynopterus sphinx*), the Egyptian fruit bat (*Rousettus aegyptiacus*), and the fulvous fruit bat (*Rousettus leschenaultia*) (Roberts, 1997, Mahmood-ul-Hassan *et al.*, 2009). Indian flying foxes in Pakistan have been reported from Islamabad, Punjab, and Sindh (Eates, 1968, Roberts, 1991, Bates and Harrison, 1997). In Pakistan, the correct number of taxa of chiropterans is still a matter of debate (Bates and Harrison, 1997, Roberts, 1997, Walker and Molur, 2003, Wilson and Reeder, 2005).

The pteropodids are generally frugivorous and rarely insectivorous while other species of bats are entirely insectivorous (Hill and Smith, 1986). For the source of food, about 29% of bats rely on plants completely or incompletely (Fleming, 1982). Bats are long live mammals (Wilkinson and South, 2002, Munshi-South and Wilkinson, 2010) and they reproduce at a low rate (Barclay and Harder, 2003). Bats have various foraging habits, community acts, reproducing scenarios, and roosting modes (Jones *et al.*, 2009). Dietary resources are the most essential limiting resources for wildlife including bats (Findley, 1993). When the sun sets, the bats depart from their roosts after 20 minutes, and their extremely large groups are separated into small groups for feeding purposes (Neuweiler, 1969). The foraging height of *Pteropus giganteus* is 8ft from ground level and they also feed on the leaves of plant species (Sudhakaran and Doss, 2012). The home range of flying foxes covers hundreds of square kilometers of area and therefore these megabats can contribute as "Umbrella" species to other species which share a common habitat with them (Suter *et al.*, 2002). The Indian flying foxes are the old-world fruit bats that play a key role in the continuity of 114 species of plants all over the world (Mickleburgh *et al.*, 1992). However, some authors suggest that 300 plant species in the old world depend on fruit bats for their survival (Marshall, 1983, Fujita and Tuttle, 1991). The most preferred roosting tree by *Pteropus giganteus* is *Ficus* but they also prefer to roost on Tasmanian blue gum or Southern blue gum, mango, and Tamarind (Venda, 2003).

Pteropus giganteus is hunted for its body fats by native homeopaths as they use it to make medicine for painful joints and they are not given any protection by the law in Pakistan (Roberts, 1997). In many regions of the world, bats are facing a high risk of endangerment (Racey and Entwistle, 2003). According to (Walker and Molur, 2003) one species of bat is endangered, four species are vulnerable, nine species are threatened, eighteen species are the least concern, seven species are data deficient, and one species is not evaluated in Pakistan. According to the IUCN Red List of Threatened Species, Indian flying foxes are classified as the least concerned (Molur *et al.*, 2008) but their population is declining as a result of habitat loss and hunting (Venkatesan, 2007). Specifically, in Southeast Asia, the large Indian flying foxes are one of the most threatened subgroups of bats (Mildenstein, 2002). Flying foxes have been placed in the fourth schedule of the Punjab Wildlife (Protection, Preservation, Conservation, and Management) Act 1974, which allows hunting of the Indian flying foxes in Pakistan (Mahmood-ul-Hassan *et al.*, 2010). The major causes leading to the population decline of flying foxes are their large size, colonial roosting habits, and large feeding areas which make them susceptible to hunting and habitat loss (Mildenstein, 2002).

The conservation of flying foxes is vital as these Megachiropterains are vital for forest renewal processes and also play a significant role in pollination and seed dispersal. There is a paucity of scientific studies on the ecology of order Chiroptera (Amori and Gippoliti, 2000). Very few studies have been conducted in Pakistan and vital ecological data required for the conservation of flying foxes are lacking in the country, therefore, the current study was designed to investigate the diet composition of flying foxes in district Kotli Azad Jammu and Kashmir, Pakistan.

Materials and methods

Study area

This study was conducted in district Kotli (33° 20' to 33 ° 40'N and 73 ° 6' to 74 ° 7' E) Azad Jammu and Kashmir, Pakistan during 2018 -2019. The average elevation of the study area is ranging from 500m to 2000 m above mean sea level. The average rainfall is 1146.08mm and the months of August and July receive maximum precipitation of about (218.82mm and 236.38mm respectively). The total area of this district is 1862 km². District Kotli consists of six tehsils including Kotli, Fatehpur Nikyal, Sehnsa, Khuiratta, Charchoi, and Dulya Jatan. District Rawalpindi is located on its western side, on its northern side district Poonch is located on its southern side Mirpur district is located and on the eastern side, Indian occupied Kashmir is located (Amjad *et al.,* 2016).

District Kotli Azad Jammu has a vast diversity of both flora and fauna. There are two national parks located in district Kotli including Pir Lasura National Park and Mahasheer National Park. Most studies have been conducted in Pir Lasura National Park, the major wildlife species reported from the park include; common leopard (*Panthera pardus*), rhesus monkey (*Macaca mulatta*), Small Indian mongoose (*Herpestes javanicus*), barking deer (*Muntiacus muntjak*), Indian grey mongoose (*Herpestes edwardsii*), Indian pangolin (*Manis crassicaudata*), the red fox (*Vulpes vulpes*),kalij pheasant (*Lophura leucomelanos*), Asiatic jackal (*Canis aureus*), Kashmir hill fox (*Vulpes vulpes grifithii)*, (Akrim *et al.*, 2017, Akrim *et al.*, 2018, Akrim *et al.*, 2018, Akrim *et al.*, 2019, Akrim *et al.*, 2019, Akrim *et al.*, 2021).

As far as the flora of District Kotli is concerned 463 plant species belonging to 306 genera and 93 families have been reported from the area. The most dominant families are Poaceae (54 spp.), Leguminosae (39 spp.), Compositae (33 spp.), Lamiaceae (23 spp.), and Rosaceae (22 spp.), whereas the leading genera were Ficus (8 spp.), Ipomoea, Cyperus, Euphorbia and Solanum (6 spp. each) (Khan *et al.*, 2015).

Study design

The field surveys of the study area were conducted during summer 2018 to 2019 for the collection of fecal pellets of Indian flying foxes. Samples were collected in the morning hours from 9 AM to 12 PM when the flying foxes were at roosting sites.

Collection of fecal samples

Samples were collected in zip bags directly below from the roosting sites as they fall on solid paved surfaces (Hodgkison *et al.*, 2003).

The samples were collected randomly from the colony of flying foxes (Parry-Jones and Augee, 2001). After the proper placements of droppings in the zip bags, these fecal pellets were brought to the lab for analysis. For each fecal pellet data related to the site of collection, global positioning system (GPS) location, and elevation were recorded.

Identification

Fecal samples of bats were washed under running tap water, by using a strainer to separate undigested food items. Then samples were dried in the oven at 70 ° C for 18 hours. Seeds recovered were identified by comparing them with reference seeds with the help of an expert using a hand lens to family and species level. Reference samples were collected from the study area within 30 km from study sites because the home range of flying foxes is approximately 30 km (Van der Pijl, 1957).

Dietary niche breadth

We computed standardized Levins index (value range 0-1) (Lst) and niche breadth (L) of Indian flying fox's diet (Levins, 1968, Colwell and Futuyma, 1971). following the formula;

$$L = \left(\sum_{i=1}^{n} p_i^2 \right)^{-1} \quad \text{and} \quad L_{st} = L - 1 / n - 1$$

Where p_i is the relative percentage of food item *i* and n is the number of food items.

L_{st} is a standardized niche breadth and its value ranges from 0 to 1. A higher L_{st} indicates a broader dietary niche of the animal.

Prey species diversity, richness and evenness

We computed different indices such as species diversity index (H'), prey richness (S), and prey evenness (E) for the prey species occurring in the diet of Indian flying fox. Prey species richness (S) represented the total number of prey species of flying foxes. Diversity Index (H') was calculated using the formula;

H'= -Σ [pi × ln pi]

where pi is the prey species index.

The Evenness Index (E) was calculated using the formula,

E = H'/ln of S

where S represents the prey species richness and H' represents the diversity index.

Data analysis

To compute our sampling effort and to estimate the diversity of prey species in the diet of flying foxes we used EstimateS software (version 9.1.0). Different diversity indices were used to compute prey species diversity including; ACE mean, ICE mean, Chao1 mean, Chao2 mean, Jack1 mean, and Jack2 mean.

Results

Fecal analysis

Analysis of 107 fecal pellets of Indian flying foxes revealed that the diet of flying foxes comprised of three plant families including Moraceae, Rosaceae, and Myrtaceae. Plants of family Moraceae dominated the diet of flying fox (78.72%) followed by Rosaceae (12.80%) and Myrtaceae (11.34%). We recovered eight plant species from guanos of flying foxes. We recovered two species belonging to the family Moraceae in the diet of flying fox including *Ficus carica* (46.73%, n=50), *Morus nigra* (29.91%, n=32). Similarly, four species of family Rosaceae were consumed including *Prunus armeniaca* (4.67%, n=5), *Eriobotrya japonica* (3.74%, n=4), *Pyrus pashia* (2.80%, n=3) and *Prunus persica* (0.93%, n=1). Whereas two species of family myrtaceae including *Syzygium Cumini* (9.35%, n=10) *Psidium guajava* (1.87%, n=2) and were consumed by flying fox (Table 1 and 2, Fig. 1). The dietary niche breadth of the Indian flying fox was 3.1 and *Lst* was 0.26.

Table 1. Diet composition of Indian flying fox in District Kotli Azad Jammu and Kashmir, Pakistan.

Prey species	Frequency (F)	Relative frequency (RF)
Ficus carica (figs)	50	46.73
Morus nigra (mulberry)	32	29.91
Syzygium cumini (jamun)	10	9.35
Prunus armeniaca (kubani)	5	4.67
Eriobotrya japonica (loquat)	4	3.74
Pyrus pashia (Himalayan wild pear)	3	2.80
Psidium guajava (guava)	2	1.87
Prunus persica (peach)	1	0.93
Total	107	100

The prey species diversity in the diet of Indian flying fox was 1.42, prey species richness was 8, and prey species evenness was 0.68.

Survey effort, prey species diversity, species accumulation curve

We recorded eight prey species in the diet of flying foxes by analyzing 107 samples. Species accumulation curves showed that our sampling effort was sufficient as at sample no 30 the curve became asymptote which showed our number of samples were sufficient to document prey species diversity in the diet of flying fox.

We reported eight prey species in the diet of flying fox whereas, different indices computed similar numbers of prey species in the diet of flying fox ranging between 8.03-9.05 which supports our data (Fig. 2).

Table 2. Contributions of three plant families in the diet of Indian flying foxes.

Families	Relative Frequency (RF)
Moraceae	78.72
Rosaceae	12.8
Myrtaceae	11.34

Discussion

We investigated the diet composition of flying foxes using fecal dropping analysis in district Kotli, Azad Jammu, and Kashmir, Pakistan during 2019 and recorded eight species from the diet of flying fox. Flying fox consumed mainly *Ficus carica*, and *Morus nigra*. Besides these species, we also recovered *Prunus armeniaca, Eriobotrya japonica, Prunus persica, Pyrus pashia, Psidium guajava,* and *Syzygium Cumini*. Our findings are in line with other authors who reported that the *Ficus* plant is a staple dietary component in the diet of these megabats. Fruits bats use *Ficus* plants as food with the combination of other plants to fulfill most of the nutritional requirements (Wendeln *et al.*, 2000). Calcium is superabundant in these fruits (Nelson *et al.*, 2000). These components in the diet are important for the development of bone, childbirth and also essential for the nourishment of young ones (Barclay, 1995, Palmer *et al.*, 2000). Few studies documented that *Pteropus giganteus* feed on *Ficus retusa* and *Ficus carica* in the winter season while, during summer it feeds on *Ficus bengalensis,* and during spring it feeds on *Ficus religiosa,* and in autumn it feeds on *Ficus carica,* these food items serve as a vital source of food for them (Wendeln *et al.*, 2000). Some fruit bats particularly *Pteropus giganteus* and *Cynopterus sphinx* uses leaves as food (Bhat, 1994), and the food selection is based on their taste preference thus causing seasonal variation in the selection of fruits (Marshall, 1983, Tidemann and Nelson, 1987). Bats consume flowers petals and leaves in their food to fulfill the requirement of proteins (Law, 1992, Kunz and Diaz, 1995, Ruby *et al.*, 2000) mostly fruits have a low amount of nitrogen, and hence proteins are considered as limiting nutrients in the diet of fruits bats (Thomas, 1984, Courts, 1998). For *Pteropus giganteus* the keystone resources are *Ficus* and *Diospyros* species because they are used as food when the other resources become deficient (Terborgh, 1986, Lambert and Marshall, 1991). Commonly bats select the fruits for their diet based on the shape, form and tasteful characters of fruit (Courts, 1998). Some authors reported that bats show a preference for different food items (Fleming and Heithaus, 1981, Tidemann and Nelson, 1987). The animals having a plant diet, mostly feed on the food which provides them maximum nutrition (Fleming, 1993, Richards, 1995). According to (Schmelitschek *et al.*, 2009) the major dietary part of bats is *Ficus* species belonging to the family Moraceae as they recovered it in maximum droppings during their study. According to some studies, the Indian flying foxes are considered a pest because they steal the fruits from the gardens (Chakravarthy and Girish, 2003, Mahmood-ul-Hassan and Nameer, 2006, Chakravarthy *et al.*, 2009).

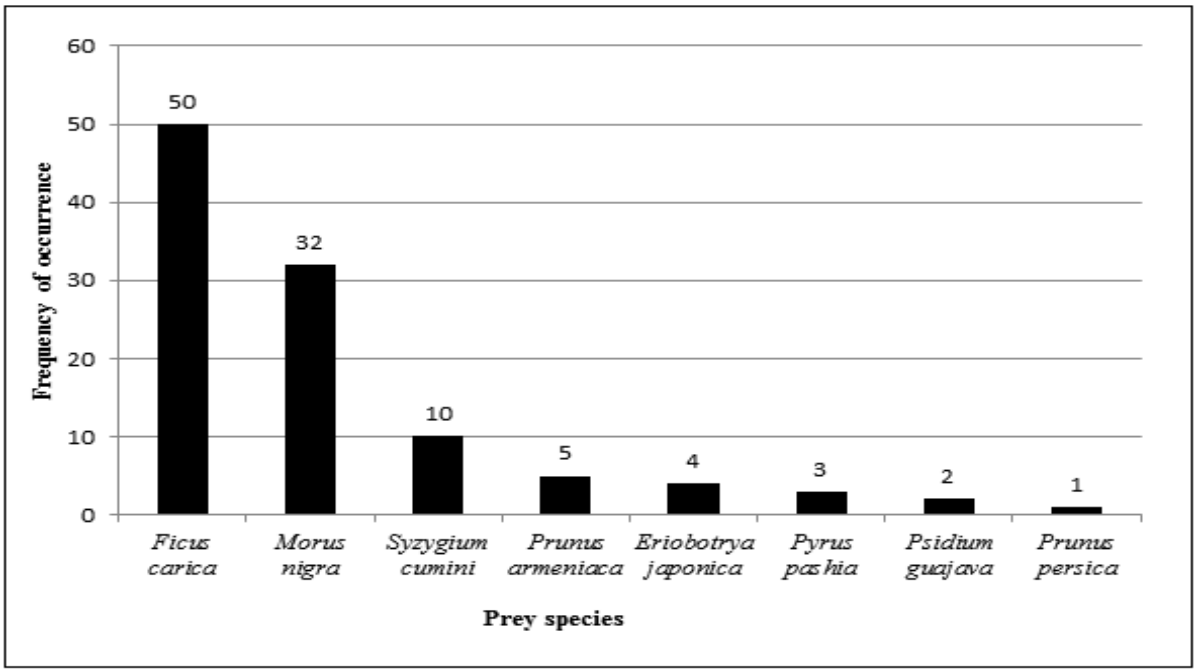

Fig. 1. Frequency of occurrence of plant species in the diet of Indian flying fox.

These bats are thought to cause heavy economic losses to plant species such as; *Acacia catechu*, *Achrus zapota*, *Psidium guajava*, *Mangifera indica*, and *Syzigium jambolanum* (Roberts, 1997, Chakravarthy and Girish, 2003). Seeds of families like Myrtaceae, Moraceae, Anacardiaceae, Ebenaceae, and Annonaceae are dispersed by flying foxes (Fujita and Tuttle, 1991). Our findings are similar to the previously published literature that flying foxes feed on fruits of plants.

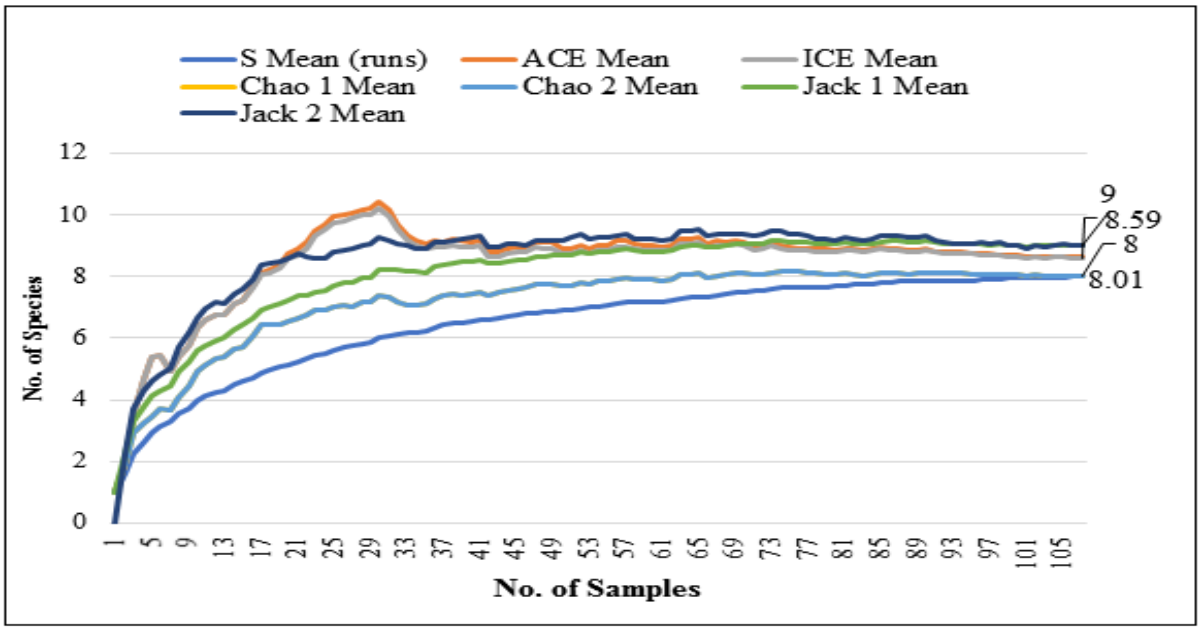

Fig. 2. Species accumulation curve of prey species recovered from 107 guano and boluses of flying foxes in district Kotli, Azad Jammu and Kashmir, Pakistan.

The difference in plant species could be due to variation in vegetation composition at different study areas of different studies reporting diet composition of flying foxes. Flying foxes are reported to feed on mature fruits, immature fruits, and also on unripe fruits. The reason behind this is the shortage of

available resources and struggle for fruits between the bats (Sudhakaran and Doss, 2012). Flying foxes fed on the mature fruits (Wiles and Fujita, 1992) which were grown from cultured plants in Pacific Island. During scarcity of food *Rousettus aegyptiacus* fed on the hard green figs (Jacobsen and DuPlessis, 1976) which were tough to break down. Many researchers highlight that fig and their dietary value vary from species to species as in recent years the work is continuing the use of figs as nutrition by bats (Wendeln *et al.*, 2000). Some researchers found that figs are used in a lower amount than other available fruits as nutrients (Milton, 1981, Borges, 1993). Whereas others argued that as compared to many other nutrients figs have high nutritional value (Nelson *et al.*, 2000). Most species of frugivorous bats consume fruits in excess amount to gain enough proteins to their diets (Thomas, 1984). But leaves and flowers both consist of many proteins (Law, 1992, Kunz and Diaz, 1995, Ruby *et al.*, 2000), and many species of megachiropteran use both flowers and leaves (Marshall, 1985). During our study we recovered mostly common species which were grown in home gardens by local communities.

The local people reported that during fruiting season (April-July) these flying foxes comes in form of groups and feed on the fruits of plants species in their gardens.

Our study showed that Indian flying foxes mostly feed on the fruits belonging to the family Moraceae as compared to other families. As genus *Ficus* and *Morus* belonging to family Moraceae contribute more to the diet of bats. While the family Rosaceae also plays an important role in the diet whereas, the family Myrtaceae contributed the least.

Conclusion

This is the first research work to report baseline data on the diet composition of Indian flying foxes *(Pteropus giganteus)* in Kotli, Azad Kashmir. We have collected data during the summer season which is the limitation of the current study therefore, it is recommended that data be collected for all four seasons to check seasonality in the diet of flying foxes. The plant species recovered from the diet of flying foxes are often orchid species, and it may raise conservation concerns as local people may develop a negative perception towards bats. We recommend that more detailed studies should be conducted to explore local perception towards bats and economic losses faced by local people because of flying foxes raiding on the orchids in the study area. We should spread awareness education among local communities about the role of bats in ecosystem functioning and to protect all plant species consumed by flying foxes in the study region.

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