BVG Trust

J. Sci. Trans. Environ. Technov. 2019, 13(1) : 31-36

Scientific Transactions in Environment and Technovation

Diet of Indian Flying Fox *Pteropusgiganteus*(Brünnich, 1782) in selected districts of Kerala and Tamil Nadu, India

https://doi.org/10.56343/STET.116.013.001.007

http://stetjournals.com

Cheruthottunkara Purushothaman Ashwin and Samidurai Jayakumar

P.G. Research Department of Zoology aand Wildlife Biology, A.V.C.College (Autonomous), Mannampandal, Mayiladuthurai - 609 305, Tamil Nadu, India.

Abstract

Chiropterans, the second largest groups of mammals in the world, at present have about 1232 species representing a quarter of the mammalian fauna, in which India fortunate enough to have 119 species of bats. A study on the diet of Indian Flying Fox in selected districts of Kerala and Tamil Nadu, India,was carried out between November 2017 and March 2018. Diet of Indian Flying Fox wasidentified using the guano/bolus, other leftover fruits and leaves under the roost sites.Totally 25 plant species were identified as the food plants of Indian Flying Fox and among the sites studied, Edakkadu, Kerala had the maximum number food plants (12 spp.) followed byPazhassi park with 11 spp. While the sites, namely Manna, Kerala and Ganthinagar, Tamil Nadu provided the minimum number of food plants with five species each. Among the plant species studied, *Ficus drupacea*and*Ficus religiosa* were the predominant food plants ofIndian Flying Fox followed by *Areca catechu, Tamarindus indica, Haldina cordifolia.* Plant species, namely *Ziziphus mauritiana, Azadirachta indica, Spondias pinnata, Coccinia grandis*and *Coffea arabica*were used minimum. Indian Flying Fox in the study sites preferred the ripe fruits rather than the unripe fruits, and it varied significantly.They depended mostly on fruits (95%) and also consume other food items like nectar (2%), tender leaves (2%) and flower (1%). Most importantly Indian Flying Fox predominantly consumed more foods from the cultivated plants than the wild plants and it directs the bats to have conflicts with farmers. Despite their beneficial roles, fruit bats have been hunted as a source of protein and for medicinal uses, and persecuted as fruit-eating pests. They are the most misunderstood species in the country and are listed in schedule V (Vermin category, which can be captured/ killed). Now it has become appropriate time for the Government of India to revisit this issue and to remove these pollinators and seed dispersers from the vermin list from Wildlife (Protection) Act 1972.

Key words: Diet, Indian Flying Fox, Bolus, Pollinators, Seed dispersal agent

Received : March 2018 Revised and Accepted : January 2019

INTRODUCTION

Bats are the most important and least understood groups of animals in the world (Bhandarkar and Paliwal, 2014). They come under order Chiroptera, the most specious order of mammals after the rodent, exhibits a great physiological and ecological diversity (Srinivasulu*et al.* 2010; Purohit*et al*. 2013; Bhandarkar and Paliwal, 2014). The feeding behaviours of bats varied from other mammals. Dietary variation of bats shows mor-phological, physiological and ecological diversity (Altring-ham, 1996). The fruit bats are virtuallyphytophagous, consuming different floral resources such as pollen, nectar, petals and bracts (Marshall, 1985).

Bats playa significant role in the agro-ecosystems, and two family such as Pteropodidae and Phyllostomidae play the significant role in plant pollinationand seed dispersaland thus provide an important ecological service by facilitating the reproductive success of plant species (Kunz *et al*. 2011).The Indian Flying Fox, is the prime pollinators of several nectariferous plants, which bloom only at night (e.g. *Ceibapentandra*, *Bassialatifolia*) and they are much more effective than birds in seed dispersal by covering larger distances at nights, while their defecation or spit out seeds during flight encourages the genetic exchanges between the fragmented and isolated populations of forests and thus decreasing the chances of inbreeding (Loveless and Hamrick, 1984; Kasso and Balakrishnan, 2013). Large-scale cash crops such as wild bananas, mangoes, agave, durians, and petai are pollinated and dispersed by the fruit bats. Among them, durians and petai are currently relying only on bats for pollination (Fujita and Tuttle 1991; Kasso and Balakrishnan 2013), which portrays the importance of fruit bats in agro-ecosystems rather considering them as fruit pests. The conflict between Indian Flying Fox and fruit growers due to crop damages over the past few decades (Roberts

*Corresponding Author :
email: *jayakumar.sacon@gmail.com*

1997; Walker and Molur 2003) made the species at risk and these disturbances cause the species in stress and lead to several viral outbreaks. The diet and diet use of Indian Flying Fox is not extensively studied in many districts of Tamil Nadu and Kerala and therefore this work is planned to fill the gap in this area of rasearch.

MATERIALS AND METHODS

This study was carried out in two districts, namely Wayanad and Kannur in Kerala and three districts, namely Nagapattinam, Thiruvarur, and Tirunelveli in Tamil Nadu during November 2017 to March 2018. The diet of Indian Flying Fox was assessed by collecting the leftover fruits, leaves and other food particles found under the roost sites of Indian Flying Fox (Sudhakaran and Doss,2012).Indian Flying Fox reported to swallow soft fruits or extract juice and spit out the remains known as the 'bolus' (Govea*et al.* 2006). The boluses and guano of *P. giganteus*were sampled for further analysis. The fresh guano/fecal samples were collected by placing the old daily newspapers/plastic sheets on the floor of diurnal roost sites (Hodgkison *et al.* 2003) and also an intensive search was made directly under each roost site for a period of 60 minutes to collect the food residues of Indian Flying Fox (Vendan and Kaleeswaran, 2011). Guano and other food residues were periodically collected in zip–lock plastic covers and transported to the laboratory nature for further analysis

The fecal samples were examined separately after being rehydrated and teased apart (Thomas, 1982; Banack, 1998). The collected remnants, including small seeds, fruits, and leaves were isolated and mounted in water and identified taxonomically (Pijl 1957).The majority of the seeds were identified through visual inspection by using a hand lens and validation was done using reference seeds and parts (Hodgkison *et al*., 2003). The separated plant materials were confirmed with help of the expertise in Forestry department, Sir Syed College Taliparamba, Kerala, and Botany department, A.V.C. College (Autonomous) Mayiladuthurai, Tamil Nadu. Seeds that could not be identified visually were germinated and identified (Hodgkison *et al*., 2003). The germination experiments involved transferring the

Table 1. Details of food plant species used by Indian Flying Fox in the study sites.

S. No.	Plant species	Family	Part eaten and condition
1	*Musa paradisiaca*	Musaceae	Ripe fruits and Nectars
2	*Spondiaspinnata*	Anacardiaceae	Ripe fruits
3	*Annonareticulata*	Annonaceae	Ripe fruits
4	*Areca catechu*	Arecaceae	Ripe fruits
5	*Bombaxceiba*	Bombacaceae	Flower
6	*Carica papaya*	Caricaceae	Ripe fruits
7	*Terminaliabellirica*	Combertaceae	Ripe fruits
8	*Terminaliacatappa*		Ripe fruits
9	*Cocciniagrandis*	Cucurbitaceae	Ripe fruits
10	*Momordicacharantia*		Ripe fruits
11	*Tamarindusindica*	Fabaceae	Ripe fruits
12	*Ficusbegalensis*		Ripe fruits
13	*Ficusdrupacea*	Morceae	Ripe fruits
14	*Ficusmicrocarpa*		Ripe fruits
15	*Ficusracemosa*		Ripe fruits
16	*Ficusreligiosa*		Ripe fruits
17	*Eucalyptus tereticornis*		Tender leaves
18	*Psidiumguajava*	Myrtaceae	Ripe and Unripe fruits
19	*Syzygiumcumini*		Ripe fruits
20	*Ziziphusmauritiana*	Rhamnaceae	Ripe fruits
21	*Coffeaarabica*	Rubiaceae	Ripe fruits
22	*Haldinacordifolia*		Ripe fruits
23	*Manilkarazapota*	Sapotaceae	Ripe fruits
24	*Capsicum frutescens*	Solanaceae	Unripe fruits
25	*Azadirachtaindica*	Meliaceae	Ripe fruits

unidentified seeds to small plastic pots containing wet cotton under natural conditions of temperature and day length (Hodgkison *et al*., 2003). The seedlings were then transferred to pots containing soil/ pots contain wet cotton and were allowed to grow until the plant species could be identified visually (Mahmood-ul-Hassan *et al*., 2010). The Phenology of the fruits and flowers preferred by Indian Flying Fox in the study sites were observed and the seasonal availability was also recorded. Preference of fruits by Indian Flying Fox in various stages of de-velopment, namely unripe and ripe were also recorded (Sudhakaran and Doss,2012). Information on the food plants and family, the nativity of plant species along with habits, and part-eaten were also recorded.

Table 2. Number of plant species used by Indian Flying Fox in various sites.

S. No.	Sites	District	State	No. of Plant species
1	Edakkad	Kannur	Kerala	12
2	Pazhassi park	Wayand		11
3	Thannitheru	Wayand		10
4	Manjalampuram	Kannur		6
5	Panamaram	Wayand		6
6	Manna	Wayand		5
7	Kudavasal	Thiruvarur	Tamil Nadu	11
8	Perabur	Nagapatttinam		9
9	Nagapatinam	Nagapatttinam		6
10	Gandhinagar	Nagapatttinam		5

RESULTS

Six roost sites of Indian Flying Fox, namelyEdakkad in Kannur district, Pazhassi park, Thannitheru, Manjalampuram, Panamaram and Manna in Wayanad Kerala and four roost sites such Kudavasal in Thiruvarur, Perampur, Nagapattinam, Ganthinagar in Nagapattinam districts in Tamil Nadu were selectedas intensive sites to understand the diet and diet use of Indian Flying Fox. Details of the plant species, family, parts eaten and conditioning of food parts used by Indian Flying Fox are shown in Table 1. A total 25 plant species belonging to 16 familieswere used by Indian Flying Fox**.** Among the roost sites studied, Edakkadu, Kerala provided the maximum number food plants (12 spp.) followed by Pazhassi Park with 11 spp. while the sites, namely Manna, Kerala and Ganthinagar, Tamil Nadu provided the minimum number of food plants with five species each (Table 2). Among the plant species, *Ficusdrupacea* and *Ficusreligiosa* were massively used by the Indian Flying Fox followed by *Areca catechu, Tamarindus indica, Haldinacordifolia*. Plant species, namely *Ziziphus*

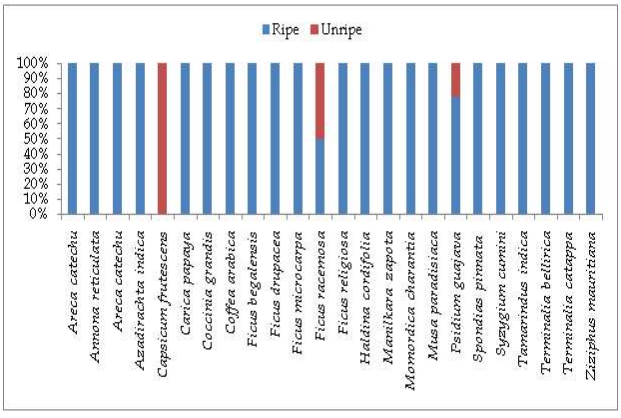

Fig 1. Dietof Indian Flying Fox based on the type of fruit.

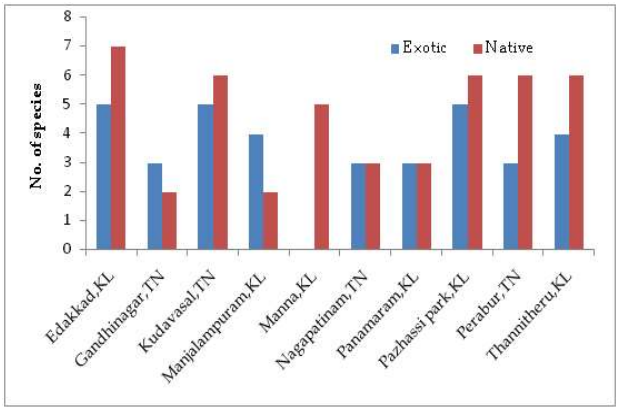

Fig 2. Diet of Indian Flying Fox based on the nativity of foods plants.

Table 3. Diet of Indian Flying Fox based on the habit of the food plants.

Roost sites	Numbers (%)		
	Climber	Herb	Tree
Edakkad, Kerala	0	3 (25)	9 (75)
Gandhinagar, Tamil Nadu	0	0	5 (100)
Kudavasal, Tamil Nadu	2 (18.20)	2 (18.20)	7 (63.60)
Manjalampuram, Kerala	0	0	6 (100)
Manna, Kerala	0	1 (20.0)	4 (80.00)
Nagapatinam, Tamil Nadu	1 (16.70)	0	5 (83.3)
Panamaram, Kerala	0	2 (33.30)	4 (66.70)
Pazhassi park, Kerala	0	3 (27.30)	8 (66.70)
Perabur, Tamil Nadu	1 (11.10)	1 (11.10)	7 (77.80)
Thannitheru, Kerala	0	2 (20.00)	8 (80.00)
Overall	40 (9)	63 (40)	81 (51)

mauritiana, Azadirachta indica, Spondia spinnata, Cocciniagrandis and *Coffea Arabica* were used less.

Various stages of fruits/parts eaten by Indian Flying Fox were collected (Figure 1). Indian Flying Fox preferred the ripe fruits rather than the unripe fruits. Nativity of food plants used by Indian Flying Fox was also assessed, and found that they used more native food plants as their major source of diet than the exotic species (Figure 2).

The diet use of Indian Flying Foxes based on the habit (climbers, herbs, and trees) of the food plant species was assessed. Among the habits, tree contributed the highest usage with 51% followed by herb (40%) and climber (9%) (Table 3). Indian Flying Fox predominantly consumed more foods from the cultivated plants than the wild plants (Figure 3).

Diet of Indian Flying Fox based on the phenology of plant species were assessed and the results showed that they use more seasonal plant species (flowering and fruiting only in particular seasons) than the perennial species (flowering and fruiting throughout the seasons) (Figure 4).

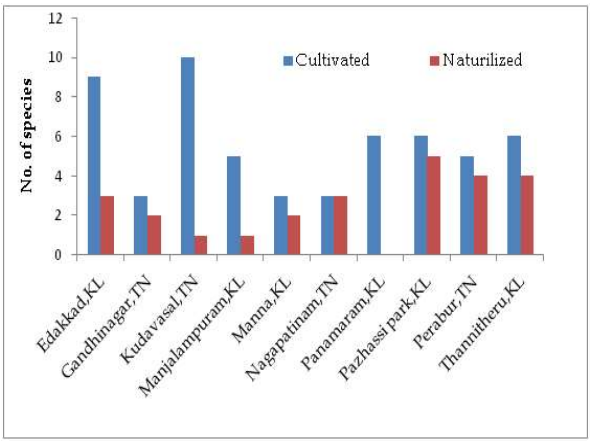

Fig 3. Diet of Indian Flying Fox based on the plant regeneration.

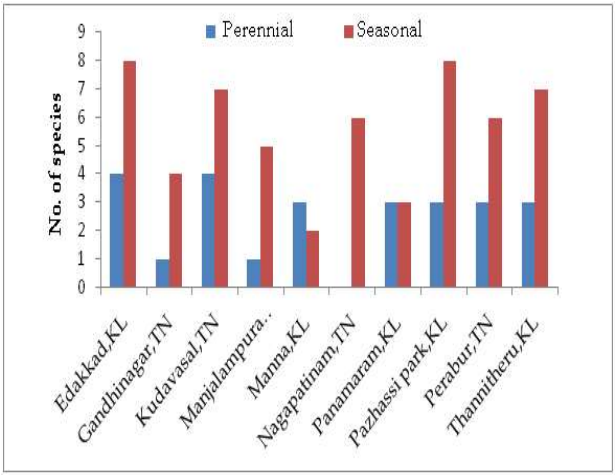

Fig. 4. Diet of Indian Flying Fox based on tree species regeneration.

DISCUSSION

Bats are active at night and known to forage in different modes based on diverse food items like insects, nectar, fruits, seeds, frogs, fish, small mammals, and even blood (Kunz *et al*. 2011). Attempts were made to study the diet and diet use of Indian Flying Fox in the present study and the results obtained in the present study is comparable with studies done in Indian subcontinents (Gulraiz*et al*.,2016; Javid *et al*.,2017). Javid *et al*., (2017) recorded a total of 32 plant species belonged to 23 genera and 15 families from the ejecta samples of fruit bats from Pakistan. Of these, eight of them were native plants and the remaining 24 were exotic, 13 were commercially important, while 19 species had no mercantile value. Similarly, Gulraiz *et al*. (2016) reported the use of 170 seeds belonging to 12 species, 11 genera, and 6 families as the diet of Indian Flying Fox in Pakistan. The results of the present study finds similarity with previous studies reported elsewhere in India. As of the present findings, it could be inferred that *P. giganteus* disperse and transport both lighter and heavier seeds which supports the findings ofGulraiz*et al*.,(2016).

Although there are no specific studies on the annual diet source of *P. giganteus* in Indiaa few sporadic reports mentioned that the areca nut (*Areca catechu*), sapota (*Achruszapota*), guava (*Psidiumguajava*), mango (*Mangiferaindica*), and jamun (*Syzigiumjambolanum*) have been widely used by Indian Flying Fox (Roberts, 1997; Chakraverthy and Girish, 2003). A study on the diet pattern of Indian Flying Fox was done using the ejected pellets, dropped fruits, fecal samples, and seeds from Madurai regions of Tamil Nadu (Vedan and Kaleeswaran,,2011). The study identified 21 plant species used by the Indian Flying Fox. Sudhakaran and Doss (2012) reported the diet and foraging behaviour of three pteropodid bats in Tirunelveli and Tuticorin districts of Tamil Nadu. They identified a total of 37 plant species as potential food plants of the pteropodid bats. The preference for fruits by pteropodids varied according to the developmental stages of fruits, namely immature, unripe and ripe (Sudhakaran and Doss, 2012). Prasad *et al*. (2014) recorded a total of 22 plant seeds from the ejected materials, chewed fruits and fecal materials from the roosting sites of Indian Flying Fox in Kerala. The diet of Indian Flying Fox recorded in the present study is comparable with earlier reports. From the present study, it could be concluded that the fruit bats consume wide varieties of plant species and play a vital role in the dispersal fruit crops having commercial values and

demand in the markets(Prasad *et al*. 2014). Hence, the Indian Flying Fox could be considered as a vital mammal species for pollination (Sudhakaran and Doss, 2012).

A number of factors could influence the food choices of Indian Flying Fox, including energy needs, requirements for specific nutrients, reproductive status, and constraints of the digestive system, abundance, diversity, seasonality of different food items, competition, and predation (Fleming, 1988). Only a few studies have investigated as to how and when the bats exploit these resources. The conflict between bats and fruit growers due to crop damage over the past few decades (Roberts 1997; Walker and Molur 2003) made the species at risk and the influence of climate change in changing paradigm of invasive proliferation in their habitats also made the species at high risk. Investigations pertaining to ecological values and ecosystem services of Indian Flying Fox are warranted to initiate the better conservation measures.Habitat destruction, degradation, and alteration are having negative impacts on bats, as these anthropogenic pressures reduce the availability of suitable roosting sites, which ultimately reduce their population size and survival, which also leads to the several zoonotic outbreaks. The public awareness on the importance of Indian Flying Fox in pollination, seed dispersal and the other benefits of their excrement (as natural organic manures) may help to preserve their roosting habitats (Fleming *et al.* 1987; Corlett, 1998; Agoramoorthy and Hsu, 2005).

Despite their beneficial roles, fruit bats have been hunted as a source of protein and for medicinal uses, and persecuted as fruit-eating pests. They are the most misunderstood species in the country and are listed in schedule V (Vermin category, which can be captured/ killed). The IUCN Red List of Threatened Species has classified this species as Least Concerned and it shows that the concerned officials are unaware of the current status of Flying Fox in India, categorizing plant-visiting bats as vermin is no longer acceptable. When the Wildlife Act was formulated (1972) there was a lack of adequate scientific evidence about the ecological roles of fruit bats, where the ecological research was in its infancy. It is now has become appropriate that the Government of India to revisit this issue and to remove these pollinators and seed dispersers from the vermin list of Wildlife (Protection) Act 1972 (Singaravelan*et al*. 2009).

ACKNOWLEDGMENT

The authors would like to thank Principaland faculty members in Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), for their support. Thanks also to the Principal Chief Conservator of Forests and Chief Wildlife Warden, Tamil Nadu Forest Department, Mr. Naga SathishGidijala, IFS, Wildlife Warden, Nagapattinam, Mr. B. Ayupkhan, Range officers, Nagapattinam division for their permission and support in the field. We express our sincere thank to The secretary, DTPC, Wayand and Park Manager Mrs. Suma for their permission and support in Pazhassi Park, Mananthavadi and Mr. Narampoo and his wife for their continuous help and support in Thiruppudaimarthur. We owe our special gratitude to Malik Fasil M, Aneesh K.S, Sneha C, Assistant Professors, Sir Syed College, Taliparamba,Keralafor their continuous help and supports throughout our study.

References

Agoramoorthy, G., Hsu, M.J., 2005. Population size, feeding, forearm length and body weight of a less known Indian fruit bat, *Latidenssalimalii*. *Curr. Sci*.88(3), 354-356.

Banack, S.A., 1998. Diet selection and resource use by flying foxes (genus *Pteropus*). *Eco.* 79, 1949-1967. https://doi.org/10.1890/0012-9658(1998)079[1949:DSARUB]2.0.CO;2

Bhandarkar, S.V., Paliwal, G.T., 2014. Population and conservation status of the Indian Flying Fox Roost in Itiadoh Dam, Maharashtra. Small Mammal Mail—Bi-Annual *Newsletter of CCINSA & RISCINSA* 6, 15–18.

Chakraverthy, A.K., Girish, A.C., 2003. Crop protection and conservation of frugivorous bats in orchards of hill and coastal regions of Karnataka. *Zoos Print J*. 18, 1169–117. https://doi.org/10.11609/JoTT.ZPJ.18.8.1169-71

Corlett, R.T., 1998. Frugivory and seed dispersal by vertebrates in the Oriental (Indomalayan) Region. *Bio. rev*. 73(4), 413-448. PMid:9951414 https://doi.org/10.1017/S0006323198005234

Fleming, T.H., 1988. The Short-Tailed Fruit Bat: A Study in Plant- Animal Interactions. Chicago, IL, USA: University of Chicago Press.

Fleming, T.H., Breitwisch, R., Whitesides, G.H., 1987. Patterns of tropical vertebrate frugivore diversity. *Annu. Rev. Ecol. Evol. Syst*. 18(1), 91-109. https://doi.org/10.1146/annurev.es.18.110187.000515

Fujita, M.S., Tuttle, M.D., 1991. Flying foxes (Chiroptera: Pteropodidae): threatened animals of key ecological and economic importance. *Conserv. Biol*. 5(4), 455-463. https://doi.org/10.1111/j.1523-1739.1991.tb00352.x

Goveas, S.W., Miranda, E.C., Seena, S., Sridhar, K.R. 2006. Observations on guano and bolus of Indian flying fox, *Pteropusgiganteus*. *Curr. Sci*.90(2). 160-162.

Gulraiz, T., Javid, A., Mahmood-Ul-Hassan, M., Hussain, S., Azmat, H., Daud, S., 2016. Role of Indian flying fox *Pteropusgiganteus* Brünnich, 1782 (Chiroptera: Pteropodidae) as a seed disperser in urban areas of Lahore, Pakistan. *Turk. J. Zool.* 40(3), 417-422. https://doi.org/10.3906/zoo-1407-42

Hodgkison, R., Balding, S.T., Zubaid, A., Kunz, T.H., 2003. Fruit bats (Chiroptera: Pteropodidae) as seed dispersers and pollinators in a lowland Malaysian rain forest. *Biotropica.* 35, 491–502. https://doi.org/10.1111/j.1744-7429.2003.tb00606.x

Javid, A., Gulraiz, T., Ashraf, M., Nadeem, M., Hussain, S.M., Altaf, M., Babu, I., 2017. Proximate analysis of Indian flying fox's *(Pteropusgiganteus)* natural food, with a note on its roost variations in urban areas of Lahore, Pakistan. Turk. *J. Zool.* 41(4), 714-721. https://doi.org/10.3906/zoo-1512-24

Kasso, M., Balakrishnan, M., 2013. Ecological and economic importance of bats (Order Chiroptera). ISRN Biodiversity, 2013.9 P. https://doi.org/10.1155/2013/187415

Kunz, T.H., Elizabeth, B.T., Dana, B., Lobova, T., Fleming, T.H., 2011. Ecosystem services provided by bats, *Ann. N. Y. Acad. Sci.*1223, 1–38. PMid:21449963 https://doi.org/10.1111/j.1749-6632.2011.06004.x

Loveless, M.D., Hamrick, J.L., 1984. Ecological determinants of genetic structure in plant populations. *Annu Rev Ecol Syst.* 15, 65–96. https://doi.org/10.1146/annurev.es.15.110184.000433

Mahmood-ul-Hassan, M., Gulraiz, T.L., Rana, S.A., Javid, A., 2010. The diet of Indian flying-foxes *(Pteropusgiganteus)* in urban habitats of Pakistan. *ActaChiropt.* 12(2), 341-347. https://doi.org/10.3161/150811010X537927

Marshall, A.G., 1985. Old World phytophagous bats (Megachiroptera) and their food plants: a survey. *Zool. J. Linn. Soc.*, *83*(4), pp.351-369 https://doi.org/10.1111/j.1096-3642.1985.tb01181.x

Maruthachalam, K., 2001. Geography, Janet Publishers Pvt. Ltd. p6.

Pijl, L. V. D., 1957. The dispersal of plants by bats (Chiropterochory). *Plant Biol.* 6(3), 291-315. https://doi.org/10.1111/j.1438-8677.1957.tb00577.x

Prasad, E.R., Dileep, P., Aryasree, M.P., Anjana, K., Sunojkumar, P., 2014. Foraging behaviour of Indian flying fox *P. giganteus* in Kerala. *Ann. Plant Sci.,* 3(11), 883-887.

Purohit, A., Soni, P., Kaur, A., Ram, H., 2013. Eco-status of Chiropteran Fauna in and around Barmer, India. *IJCS* 4 (1), 119–123.

Roberts, T.J., 1997. The Mammals of Pakistan. Revised Ed. Oxford Univ. Press. Oxford.

Srinivasulu, C., Racey, P.A., Mistry, S., 2010. A key to the bats (Mammalia: Chiroptera) of South Asia. *JoTT.*2 (7), 1001–1076. https://doi.org/10.11609/JoTT.o2352.1001-76

Sudhakaran, M.R., Doss, P.S., 2012. Food and foraging preferences of three pteropodid bats in southern India. *JoTT.* 4(1), 2295-2303. https://doi.org/10.11609/JoTT.o2227.2295-303

Thomas, D.W., 1982. The ecology of an African savanna fruit bat community: resource partitioning and role in seed dispersal (Doctoral dissertation, University of Aberdeen).

Thomas, K.A., 2015. Floristic studies on some dark spored agarics of Kerala.

Vendan, S.E., Kaleeswaran, B., Baskar, K., Anand, A.A.P., 2008. Conservation status of Indian flying fox, *Pteropus giganteus* in Tamil Nadu, South India. Wildlife Biodiversity Conservation. New Delhi, India: M. Daya Publishers: 81-91.

Vidyavathi, V., Seetha, Subramanian., 2005. Geography and Economics Macmillan India Limited. Chennai, p25.

Walker, S., Molur, S., 2003. Summary of the status of South Asian Chiroptera. Extracted from C.A.M.P2002 Report. Zoo Outreach Organization CBSG South Asia and Wild, Coimbatore, India.