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Proximate analysis of Indian flying fox's (*Pteropus giganteus*) natural food, with a note on its roost variations in urban areas of Lahore, Pakistan

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Abstract: Food habits, nutrient preferences, and roost variations of Indian flying fox *Pteropus giganteus* were investigated for a period of 1 year in two public parks in Lahore, Pakistan. Bolus and guano samples of *P. giganteus* were collected on a monthly basis, and seeds of 32 plant species belonging to 23 genera and 15 families were identified from the ejecta samples. Of these 32 food species, 8 were native and 24 were exotic; 13 were commercially important, while 19 species had no mercantile value. Proximate analysis of the food items revealed that fruits with comparatively higher moisture content were utilized during summer; fruits having relatively higher carbohydrates, fibers, protein, fats, phosphorous, iron, and sodium were used during winter; diets having relatively greater calcium and vitamin C contents were used during autumn; and phosphorous-rich diets were used during spring. Permanent roosting trees (n = 50) representing 17 families, 19 genera, and 21 species were monitored to record the abundance and roost fidelity of *P. giganteus*. The maximum number of bats (n = 425) was recorded for *Dalbergia sissoo* during summer, *Kigelia pinnata* (n = 270) during spring, *Celtis australis* (n = 374) during autumn, and *Cedrela toona* (n = 330) during winter.

Key words: Roost fidelity, seasonal food, proximate analysis, nutrient preference, ejecta, *Pteropus giganteus*

1. Introduction

Pteropus giganteus is one of the largest fruit bats and forms large communal open day roosts on trees in public parks, village surroundings, towns, home gardens, temples, roadside plantations, agricultural fields, and factory campuses. The species is an important pollinator and seed disperser and hence plays a significant role in maintenance of local plant communities (Digana et al., 2000; Yapa et al., 2000; Louis et al., 2008). In Pakistan, roosting sites of *P. giganteus* were recorded from Sialkot (USNM), Lahore, Maralla, Renala Khurd, and Said Pur in Punjab Province and from Jacobabad, Shahpur, and Karachi in Sindh Province. Banyan trees (*Ficus bengalensis*), paper mulberry groves (*Broussonetia papyifers*), and *Albizzia* trees served as bat roosts (Roberts, 1977). In South Asia, the flying foxes are among the most maltreated species (Molur and Molur, 2007), and they are listed on Appendix II of CITES (Molur et al., 2002).

Previously, it was assumed that flying foxes consume only fruits and do not supplement their diets with other food materials; hence, organic nutrient protein (nitrogen) was considered as the major limiting nutrient in the diet of *P. giganteus* (Thomas, 1984; Herbst, 1986; Steller, 1986). However, it was later reported that the diet of flying foxes includes much more than just fruit (Banack, 1996; Courts, 1998). *P. giganteus* has been reported as deliberately ingesting insects, pollen, and leaves, possibly to provide extra protein in the diet (Thomas, 1991; Mickleburgh et al., 1992; Kunz and Ingalls, 1994; Kunz and Diaz, 1995; Kunz et al., 1996; Nogueira and Peracchi, 2003). A number of factors can influence the food choices of flying foxes, including energy needs, requirements for specific nutrients, reproductive status, constraints of the digestive system, abundance, diversity, seasonality of different food items, competition, and predation (Fleming, 1988). In response to the loss of native fruit species, flying foxes are likely to be attracted by introduced fruit species, some of which have commercial value (Charles-Dominique, 1991). Flying foxes acquire shelter and energy from plants and in turn disperse the pollen and seeds of the plants (Ganesh and Davidar, 2001). Furthermore, it has been documented that the ecological services rendered by these bats outweigh

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the losses, such as damage to the ripe fruit (Mahmood-ul-Hassan et al., 2010). Therefore, conservation of *P. giganteus* should be ensured in government policies and private land management for proper maintenance of natural ecosystems (Kunz et al., 2011).

The decline in *P. giganteus* populations is a consequence of habitat destruction, deforestation, urbanization, and conflict between bats and fruit growers due to crop damage over the past few decades (Roberts, 1997; Walker and Molur, 2003). Despite the number of ecological services rendered, *P. giganteus* is considered a pest in Pakistan and has been given no protection by the law (Mahmood-ul-Hassan et al., 2009; Kunz et al., 2011).

The first step to the conservation of this species in Pakistan is to determine the population status of *P. giganteus* in the country and to understand the interaction of this species with local plant communities. The present study was therefore designed to assess seasonal roost variations and nutritive composition of natural food items consumed by *P. giganteus* in urban areas of Lahore, Pakistan.

2. Materials and methods

2.1. Study area

This 1-year study extending from January 2011 through December 2011 was conducted in Lahore, Pakistan. Lahore is the second most populous city in Pakistan, at an altitude of 208–213 m above mean sea level (5.74 m) and experiences extreme summer and winter seasons, with the annual temperature fluctuating between 4 °C and 40.4 °C (NESPAK and LDA, 2004). Annual rainfall is 629 mm, but the rains are more frequent during the monsoon season (July–September). Roosting sites of *P. giganteus* were observed at two public parks, Jinnah Garden (35°55′N, 74°33′E) and Lalazar Garden (31°28′N, 74°14′E), in Lahore. Jinnah Garden covers an area of 56.7 ha and has been divided into 47 plots. Roosts of *P. giganteus* were observed on the trees in 4 plots, i.e. plot numbers 4, 5, 6, and 7, covering 8.5% of the total garden area and harboring 12.3% of total trees present in the garden. Lalazar is a small garden covering 1.6 ha of land, and *P. giganteus* was observed residing in 8% of the trees in the garden. The Badian Ravi Bombanwala canal runs within a few meters' distance of both gardens. Availability of waterbodies near bat roosts is important, as *P. giganteus* drinks water from nearby ponds (Chakravarthy et al., 2009) and prefers to roost near waterbodies (Gulraiz et al., 2015).

2.2. Food analysis

A total of 192 ejecta (bolus and guano) samples of *P. giganteus* were collected during the 1-year study period. A polythene sheet (1 m × 1 m) was spread directly under the most populated roosts overnight, and the ejecta samples were picked up randomly on the subsequent day. The samples were placed in zipped plastic bags and were tagged with roost number, plot number, and date of collection. The samples were processed further to separate seeds from the adhering ejecta and were transferred to 20 mL of distilled water and shaken well to separate the undigested food items. The seeds thus separated from the boluses and guanos were identified by matching them with a reference collection of seeds collected from plants in the Jinnah and Lalazar gardens within a circumference of 30 km, which is the distance *P. giganteus* can commute per night (van der Pijl, 1957). The unidentified seeds were germinated by placing them into small plastic pots containing wet cotton under natural conditions (Hodgkison et al., 2003). The seedlings were then transferred to pots containing soil and were allowed to grow until plant species could be identified (Mahmood-ul-Hassan et al., 2010).

2.3. Proximate analysis

Seeds are valued for both nutritional and economic values and are a rich source of protein (Coudert, 1982). Fruit has low protein content; to obtain protein, flying foxes ingest small seeds of many plant species, particularly figs, which pass through their gut and are expelled in feces (Janzen, 1978). Seeds separated from ejecta were air-dried in an oven at 40 °C, crushed manually into a fine powder, and kept at 5 °C in polyethylene bags before analysis. Seed moisture, crude protein, crude fiber, and fats were determined following Pearson (1976); ash content was determined following Pomeranz and Meloan (1994); and total carbohydrates were determined by subtraction. Concentrations of calcium, sodium, iron, potassium, and phosphorus were determined using an atomic absorption spectrometer (PerkinElmer AA Analyst 700) following Elaroussi et al. (1994). Vitamin C content was determined by application of the 2,6-dichloroindophenol volumetric method (AOAC, 1990).

2.4. Roost count

A total of 50 roosting trees of *P. giganteus* were located at Jinnah (n = 44) and Lalazar (n = 6) gardens. These roosting trees were identified and visited on a monthly basis throughout the year to count bats roosting on each tree; moreover, all trees in both gardens were counted and listed. Each roost tree was assigned a specific number, and if an additional tree was found to have roosts in successive months, it was added to the preexisting list of tree roosts to determine monthly variations in the number of bats roosting. Four observational techniques—direct roost counts, disturbance counts, nightly dispersal, and nightly emergence counts—were employed for observing bats (Kunz et al., 1996). Counts were made either soon after sunrise or during late afternoon (Findley and Wilson, 1983). The bats were counted on each branch by naked eye; binoculars were used only to clarify confusion between the presence of a bat or a cluster of trees. Seasonal roost variations (%) were calculated by the following formula:

$$\text{Seasonal roost variations (\%)} = \frac{\text{No. of bats on roost in season}}{\text{Total no. of bats on all the roosts in that season}} \times 100$$

3. Results and discussion

A total of 4209 trees belonging to 46 families, 103 genera, and 132 species were recorded at Jinnah Garden and Lalazar Garden; out of those, 50 trees belonging to 17 families, 19 genera, and 21 species served as *P. giganteus* roosts (Table 1). Preferred roosting tree species include *Syzygium jambolanum* (n = 13), *Mangifera indica* (n = 6), *Manilkara hexandra* (n = 6), *Ficus glomerata* (n = 4), *F. elastic* (n = 2), *F. retusa* (n = 2), *Bombax ceiba* (n = 2), and *Dendrocalamus hamiltonii* (n = 2) (Table 1). These thick canopy trees were located near manmade rills used to irrigate the garden. *F. glomerata*, *F. retus*, *M. indica*, and *S. jambolanum* were also consumed by these bats in their respective fruiting seasons. Chakravarthy et al. (2009) documented that roost trees of *P. giganteus* in urban areas generally include *Ficus* spp., *Delonix regia*, *Eucalyptus* spp., *Acacia* spp., *Terminalia* spp., *Casuarina* spp., *Tamarindus indica*, *Mangifera indica*, and *Artocarpus heterophyllus*.

During the present study, the maximum number of bats (n = 1059; 8.38%) was observed on *Putranjiva roxburghii* (n = 1) and the minimum (n = 111; 0.88%) on *M. hexandra* (n = 6). Seasonal roost variations were observed; the maximum number of bats (n = 270; 11.3%) was recorded on *K. pinnata* during spring, *Dalbergia sissoo* (n = 425; 12.81%) during summer, *Celtis australis* (374; 10.62%) during autumn, and *Cederala toona* (330; 9.67%) during winter (Table 1). Dey et al. (2013) conducted similar research on *P. giganteus* in Purulia District, India, and documented seasonal variations. More bats were counted during colder months of the year (260 in November) as compared to hotter months (120 in May). Chakravarthy et al. (2009) documented *Heritiera papilio*, *Dysoxylum malabaricum*, and *Chukrasia tabularis* as the most preferred species for roosting of *P. giganteus*. *P. giganteus* exhibited incredible seasonal change in roost composition, roost size, and roost shifting; this behavioral pattern might be a response to weather change and food availability. Similar behavior has been observed in other species of the genus *Pteropus* (Mickleburgh et al., 1992; Pierson and Rainey, 1992; Roberts, 1997; Wiles et al., 1997).

P. giganteus populations were year-round residents of Jinnah and Lalazar gardens; however, they showed some local movement. Jinnah Garden was previously reported as a *P. giganteus* roost by Roberts (1997), whereas Lalazar Garden had been reported only recently. Our findings are in line with Bell et al. (1986) and Kunz (1982), who reported that populations of flying foxes did not show distant migrations but only local movement in California and eastern Australia, respectively.

Nutritional value is important in food selection, and flying foxes in nature appear to meet their nutrient needs by consuming large quantities of a mixture of fruits, with consumption of flower parts, pollen, leaves, bark, seed pods, cones, twigs, and insects (Mickleburgh et al., 1992; Ange et al., 2001; Long and Racey, 2007). Records of seed predation have also been reported (Bonaccorso, 1979; Thomas, 1991; Nogueira and Peracchi, 2003). Two possible reasons for eating a variety of fruit species are: (1) a preferred species, which could alone fulfill the bat's nutritional needs, may not always be available, or (2) no single fruit species is sufficient to meet the bat's nutritional needs (Fleming, 1986). Nutrients gained from seed predation reduce the number of figs ingested each night, which would limit the number of foraging trips and thus be advantageous (Kalko et al., 1996).

Seasonal variations in the diet of *P. giganteus* were recorded, and the proximate analysis of their natural diet (Table 2) showed that these flying foxes are highly remarkable in selecting food items in particular seasons. Seeds of 32 plant species belonging to 23 genera and 15 families were identified from the ejecta samples of *P. giganteus*. It was observed during the analysis that these bats consumed fruits showing increased levels of particular nutrients according to their body requirements in a particular season. The proximate analysis of identified plant species from ejecta samples of *P. giganteus* showed that *M. indica* served as a major source of moisture during autumn and spring, while *D. peregrina* was utilized throughout the year as a source of fiber. During winter, *E. melliodora*, with higher carbohydrate contents, and *P. chinensis*, rich in fat, phosphorus, and iron, were taken as food. *M. zapota* and *D. melanoxylum*, with higher K and Na contents, were utilized during spring and summer, while *M. altisimia*, rich in protein and vitamin C, was used during autumn and winter (Table 2).

The dietary items consumed during summer were comparatively rich in moisture content (53.49%); during winter, diets with relatively higher protein (9.58%), fat (7.26%), fiber (12.20%), phosphorus (5.60%), and iron (4.07%) were ingested. Diets that were relatively higher in vitamin C (9.26%) were preferred during autumn, and diets higher (3.41%) in potassium were consumed during spring (Table 3).

Flying foxes supplement their food with a variety of plant materials to fulfill their protein requirements. Apart from an extensive list of dietary items, flying foxes have been observed consuming seeds; however, few records of seed consumption in flying foxes are available (Kunz and Diaz, 1995; Ruby et al., 2000; Nogueira and Peracchi, 2003). Flying foxes gained 25% to 33% of their total energy from the seeds; seeds also contain 30% protein, though fruit itself has low protein content, and is rich in minerals

Table 1. Seasonal variations in the populations of Indian flying fox (*Pteropus giganteus*) at Jinnah and Lalazar gardens, Lahore.

Family	Roost species (no. of trees)	Common name	No. of bats/year (%)	Spring (%)	Summer (%)	Autumn (%)	Winter (%)
Jinnah Garden							
Anacardiaceae	*Mangifera indica* (4)	Mango	272 (2.15)	81 (3.40)	129 (3.89)	47 (1.33)	15 (0.44)
Apocynaceae	*Alstonia scholaris*	Indian devil	713 (5.64)	197 (8.26)	91 (2.74)	163 (4.63)	262 (7.68)
Bignoniaceae	*Kigelia pinnata*	Sausage	898 (7.11)	270 (11.33)	211 (6.36)	192 (5.45)	225 (6.59)
Cannabaceae	*Celtis australis*	European nettle	829 (6.56)	161 (6.75)	112 (3.38)	374 (10.62)	182 (5.33)
Combretaceae	*Terminalia arjuna*	Arjun	495 (3.92)	54 (2.27)	267 (8.05)	129 (3.66)	45 (1.32)
Cuperssaceae	*Taxodium mucronatum*	Sabino	360 (2.85)	23 (0.96)	85 (2.56)	147 (4.17)	105 (3.08)
Ebaneceae	*Diospyros peregrina*	Gaabh	901 (7.13)	134 (5.62)	243 (7.33)	286 (8.12)	238 (6.98)
Fabaceae	*Albizzia procera*	White siris	631 (4.99)	126 (5.29)	110 (3.32)	142 (4.03)	253 (7.42)
	Dalbergia sissoo	Indian rosewood	1055 (8.35)	74 (3.10)	425 (12.81)	330 (9.37)	226 (6.62)
Lauraceae	*Cinnamomum camphora*	Camphor	455 (3.60)	80 (3.36)	22 (0.66)	158 (4.49)	195 (5.72)
Malvaceae	*Bombax ceiba* (2)	Cotton	427 (3.38)	100 (4.19)	103 (3.11)	100 (2.84)	124 (3.63)
	Pterospermum acerifolium	Dinner plate	679 (5.37)	67 (2.81)	202 (6.09)	135 (3.83)	275 (8.06)
Meliaceae	*Cedrela toona*	Cedrus	766 (6.06)	187 (7.84)	65 (1.96)	184 (5.23)	330 (9.67)
Moraceae	*Ficus elastic* (2)	Rubber	359 (2.84)	69 (2.89)	20 (0.60)	99 (2.81)	171 (5.01)
	F. glomerata (4)	Cluster fig	357 (2.83)	45 (1.89)	82 (2.47)	138 (3.92)	92 (2.70)
	F. retusa (2)	Ficus microcarpa	389 (3.08)	72 (3.02)	180 (5.43)	113 (3.21)	24 (0.70)
Myrtaceae	*Syzygium jambolanum* (9)	Jambolan plum	180 (1.42)	43 (1.80)	101 (3.04)	27 (0.77)	9 (0.26)
Poaceae	*Dendrocalamus hamiltonii* (2)	Giant bamboo	961 (7.61)	246 (10.32)	336 (10.13)	181 (5.14)	198 (5.80)
Putranjivaceae	*Putranjiva roxburghii*	Drypetes	1059 (8.38)	213 (8.93)	356 (10.73)	304 (8.63)	186 (5.45)
Rutaceae	*Aegle marmelos*	Wood apple	737 (5.83)	126 (5.29)	159 (4.79)	217 (6.16)	235 (6.89)
Sapotaceae	*Manilkara hexandra* (6)	Rayan	111 (0.88)	16 (0.67)	18 (0.54)	55 (1.56)	22 (0.64)
Total number of bats				2384	3317	3521	3412
Mean				113.52	157.95	167.67	162.48
Standard deviation				73.48	113.89	91.91	97.17
Range				16–270	18–425	27–374	9–330
Lalazar Garden							
Anacardiaceae	*Mangifera indica* (2)	Mango	329 (27.62)	102 (30.27)	95 (37.85)	60 (21.13)	72 (22.57)
Myrtaceae	*Syzygium jambolanum* (4)	Jambolan plum	862 (72.38)	235 (69.73)	156 (62.15)	224 (78.87)	247 (77.43)
Total number of bats				337	251	284	319
Mean				168.5	125.5	142	159.5
Standard deviation				94.05	43.13	115.97	123.74

Table 2. Proximate analysis of food tree species identified from ejecta of the Indian flying fox (*Pteropus giganteus*) from Jinnah and Lalazar gardens, Lahore.

Family	Species	Season	Moisture	Protein	Fat	Fiber	Carbohydrate	Ca	P	Fe	Vitamin C	K	Na
Anacardiaceae	*Mangifera indica*	Spring, summer	86.10	0.60	0.10	1.10	11.80	0.01	0.02	0.30	13.00	1.43	0.01
	Pistachia chinensis	Winter	4.36	20.61	51.78	3.99	25.97	10	45	42	0.10	18	5.0
Annonaceae	*Polyalthia longifolia*	Spring	8.90	12	10	13.96	37.18	1.94	2.50	1.12	0.42	2.39	0.52
Arceaceae	*Areca catechu*	Summer, winter	40.6	6.5	0.13	12.12	20.13	1.54	1.8	1.62	29.31	1.24	2.2
	Livistonia chinensis	Summer, autumn	7.14	5.04	3.38	3.65	33.65	1	4	1	56	4	0.01
Bignoniaceae	*Kigelia pinnata*	Summer	75.4	0.8	0.9	4.3	12.2	5.61	1.12	0.2	0.29	6.9	4.1
Combretaceae	*Terminalia catappa*	Autumn, winter	3.13	18.78	16.35	2.32	16.02	5.27	2.20	3.8	0.30	0.17	2.78
Ebanaceae	*Diospyros kaki*	Summer, autumn	79.68	1.04	0.21	2.3	8.00	16	1.74	0.3	7.0	1.30	0.6
	D. melanoxylon	Summer	7.88	5.46	4.56	23.28	28.6	9.6	4.6	1.03	2.46	4.1	10.7
	D. peregrina	All 4 seasons	8	1.9	0.3	55	17	2.7	2.6	2.5	6.6	3.1	1
Euphorbiaceae	*Mallotus philipensis*	Summer	4.06	9.9	11	50.0	47.1	2.13	0.14	2.9	1.9	0.25	0.01
Fabaceae	*Mellilotus altissimia*	Autumn, winter	68	28.3	1	30.8	18.1	2.15	3.07	3.07	2	1.95	1.03
Malvaceae	*Ceiba petendra*	Autumn	7.01	11.12	2.31	19.50	22.65	10.12	1.24	1.32	0.97	7.85	4.13
Meliaceae	*Melia azadrach*	Winter	9.02	6.89	2.37	30.42	55.78	0.37	12.91	0.2	3.02	1.81	9.67
Moraceae	*Ficus carica*	Autumn	70.70	1.03	0.20	15.7	16.10	0.04	0.05	1.01	1.91	2.32	1.0
	F. macrophylla	Summer, autumn	67.7	4.3	1.7	4.1	64	2.2	1.33	2.1	2.7	0.8	0.9
	F. glomerata	Summer, autumn, winter	45.00	6.59	4.95	18.09	47.00	1.7	4.0	1.01	5.0	1.10	2.0
	F. religiosa	Spring, winter	55	7.99	5.92	15.9	27.09	13.5	3.3	0.01	4.40	2.9	1.0
	F. retusa	Spring, summer	60	3.0	1	10	20.35	6.5	3.2	3.1	2.09	2.08	1.7
	F.virens	Summer, autumn	50	3.52	6.0	8.9	12	4.9	2.1	1.90	0.3	3.01	2.2
	Morus nigra	Spring	12.98	2.03	0.70	2.05	50.04	1.66	0.11	2.06	1.05	5.21	4.16
Myrtaceae	*Callistemon citrinus*	Spring, winter	4.25	6.0	5.90	18.9	48.2	0.8	1.1	0.1	39.2	1.1	0.08
	Eucalyptus cameldulensis	Spring, winter	4.33	7.0	3.00	14.89	78	2.7	1.42	0.8	1.49	1.2	3.39
	E. citridora	Spring, winter	4.51	5.67	2.89	15	60	2.9	1.39	0.4	1.50	1.5	4.23
	E. melliodora	Winter	8	10.77	3.02	1.22	80	1.51	2	1	1	0.9	3.10
	Melaluca leucandenron	Spring, summer, winter	8.7	7.9	4.0	1	10.7	0.3	0.10	0.4	1	0.5	0.7
	Psidium guajava	All 4 seasons	84	0.54	0.21	4.99	10.10	0.04	0.09	2.20	12.00	0.29	0.19
	Syzygium jambolanum	Spring	55	0.69	0.20	1.00	16.98	0.03	0.05	1.10	33.48	0.31	0.04
Rubiaceae	*Anthocephalus cadamba*	Spring	30	15.51	1.02	20.72	40	2.0	0.02	1.0	0.25	1.0	0.1
Sapindaceae	*Nephelium lappaceum*	Spring, autumn	0.85	0.51	0.23	0.04	6.00	1.6	0.4	2.47	11	8.4	1.99
Sapotaceae	*Manilkara zapota*	Spring	82.2	0.3	0.01	2.6	16.69	2.0	2.0	6.0	0.6	19.7	5.9
	Medhuca longifolia	Spring	7.73	8.5	10.8	15.92	12.12	4.0	0.12	0.2	0.7	1.58	0.02

Table 3. Nutrient profile of seeds identified from ejecta of the Indian flying fox (*Pteropus giganteus*) from Jinnah and Lalazar gardens, Lahore.

Nutrient profile	Season			
	Spring	Summer	Autumn	Winter
Moisture %	33.9	53.49	41.94	30.36
Protein %	4.48	6.89	5.24	9.58
Fat %	2.31	2.93	3.9	7.26
Fiber %	8.32	8.38	11.22	12.2
Carbohydrate %	29.31	22.43	24.39	36.35
Ca %	1.89	3.41	3.75	3.06
P %	0.77	1.65	1.45	5.6
Fe %	1.55	1.61	1.85	4.07
Vit. C %	9.03	8.14	9.26	8.09
K %	3.41	1.77	2.48	2.44
Na %	1.73	1.18	1.33	2.53

and vitamins (Morrison, 1980). It was observed during the present study that *P. giganteus* ingested seeds. Vitamin C intake during autumn and winter was recorded at a maximum of 9.26% and a minimum of 8.09%, respectively (Table 3). Vitamin C (ascorbic acid) plays an important role as an antioxidant and in collagen synthesis. Most vertebrates are able to synthesize vitamin C, but *Pteropus* spp. and *Vesperugo abramus*, from two different suborders (Megachiroptera and Microchiroptera, respectively), are unable to synthesize it and thus are dependent upon the intake of plant material to meet their daily requirements of vitamin C (Birney et al., 1980).

The fruits and seeds of *Diospyros* and *Ficus* spp. are vital food resources for *P. giganteus* and consumed by these bats throughout the year, even in periods of inadequate food resource availability (Table 2). The fruits of *Ficus* species are 78% seeds; the tiny seeds were ingested and digested by flying foxes and a higher proportion of viable seeds was also found in guano as compared to bolus. This may render long-distance dispersal, which may occur through guano deposition more effectively, and also provide essential nutrients to flying foxes (Terborgh, 1986; Lambert and Marshall, 1991; Reiter, 2002). Seed predation can be considered an important way by which bats maximize nutritional intake, expanding our view of the trophic roles played by this group. Better understanding the factors responsible for the high bat diversity in tropical ecosystems, as well as protecting such diversity, depends greatly on the clarification of these trophic roles (Kalko, 1997; Fenton et al., 2001).

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