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Food and foraging preferences of three pteropodid bats in southern India

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Abstract: A study on the food, foraging and flight height in three species of pteropodid bats, namely *Cynopterus sphinx, Rousettus leschenaultii* and *Pteropus giganteus* was conducted in Tirunelveli and Tuticorin districts of southern Tamil Nadu, India. A total of 37 species of plants were identified 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. There is a relationship between the foraging activities of bats and the moon phase. Bats exhibit a varied foraging pattern and flight height. A variation in the foraging flight height was observed in *C. sphinx* and *R. leschenaultii*. *R. leschenaultii* was observed to have a higher foraging echelon than that of the *C. sphinx*. In our study we found that the *C. sphinx* forages normally at canopy level (up to 3.5m), *R. leschenaultii* forages at upper canopy levels (up to 9m) and *P. giganteus* at a height above the canopy area (>9m).

Keywords: Flight height, food preference, foraging, phenology.

INTRODUCTION

The feeding habits of bats as a whole are as varied as that of other mammals, and this dietary variation is proportional to much of the morphological, physiological and ecological diversity seen in bats (Altringham 1996). Most of the bats are relatively stereotyped in their foraging preferences. Pteropodid bats are usually frugivorous but very rarely insectivorous where as all other bats are exclusively insectivorous (Hill & Smith 1986). It has been estimated that approximately 29% of the bats, partially or wholly, are dependent on plants as a source of food (Fleming 1982).

Pteropodids are known to be virtually phytophagous; studies also reveal that the diet of fruit bats includes several other floral resources (largely nectar and pollen but also petals and bracts), fruits (i.e. any plant material surrounding seeds), often the seeds themselves and leaves (Marshall 1985). In addition to seasonal patterns of fruit availability, frugivorous bats face highly inter-specific variations in the timing and amount of food production (McKenzie et al. 1995). Although individual species have restricted fruiting seasons, several species of bat eat fruits that are generally available at all times of the year in tropical habitats. Food resources exploited by bats vary widely in their spatio-temporal distributions (Fleming 1982; McKenzie et al. 1995; Hodgkinson 2001). In addition to playing an important role in determining the structure of tropical bat communities, frugivory and nectarivory reflect plant adaptations, which facilitate seed dispersal and pollination. Bats have been found to have various foraging strategies from the gleaning level to the aerial hawking level of flight. The factors for the flight of bats were well discussed by Fenton et

al. (1987) and Norberg & Rayner (1987).

This paper deals with the phenology of bat depending plants and the foraging patterns of the pteropodid bats including, *C. sphinx*, *R. leschenaultii* and *P. giganteus*. Plant parts preference and seasonal availability of the food has also been discussed.

MATERIALS AND METHODS

The study on the food, foraging and flight height of three species of pteropodid bats was conducted from May 2008 to April 2009 in Tirunelveli (08^{0}8'N & 77^{0}54'E) and Tuticorin (08^{0}45'N & 78^{0}13'E) districts of southern Tamil Nadu. In this study, plants that provide food to frugivorous bats, foraging pattern and flight height in pteropodid bats were assessed.

Weekly field trips were made to observe the wide range of foraging habitats of bats. Observations were made to find the food items preferred by bats. Food remnants viz., chewed fruits, bolus and floral remnants were collected from the bat flyways and below the day and night roosts. The collected remnants were analyzed to identify the plant species. The Phenology of the fruits and flowers preferred by bats in the study area were observed and their seasonal availability was assessed. Preference of fruits in various stages of development (immature, unripe and ripe) by bats was observed for a few species of plants throughout their fruiting seasons. Variations in the foraging strategies and foraging bouts among the frugivorous bats were also studied. The influence of moonlight on the foraging pattern of the frugivorous bats was estimated.

The flight height of pteropodid bats in the foraging area (orchards and wild trees) was studied by using the mist netting sampling method. The foraging areas of fruit bats were classified into two types. One is below the canopy level (below 3.5m height) and the other is above the canopy level (which is above 3.5m height). For capturing *C. sphinx* and *R. leschenaultii,* mist nets (Avinet Dryden Inc. USA) with a mesh size of 3.5 x 3.5 cm were used and for capturing *P.giganteus*, nets with a mesh size of 16 x 16 cm were used (custom made mist nets). Apart from the bats captured through the mist nets, bats that came to the foraging trees were also monitored and noted. The fruiting trees for netting were selected in a manner that would be preferred by the three species of frugivorous bats and also where their diurnal roosting site was nearer to the foraging area. The mist netting exercise commenced about half an hour before dusk and was completed at 0600hr in the morning. Mist nets were erected from a height of 1.5–30 m and the bats captured at various netting heights were recorded. The captured bats were classified according to their age, sex and reproductive status. Captured bats were marked with a special kind of necklace (Issac et al. 2003), kept in a cage and released before dawn.

RESULTS

A total of 37 species of food plants were identified. These plants provide fruits or their parts, leaves, flowers, nectar and pollen for pteropodid bats including *Cynopterus sphinx*, *Rousettus leschenaultiii* and *Pteropus giganteus* in the study area (Table 1).

Food of pteropodid bats

The bats fed on fruits, leaves, nectar and pollen. A variation of food selection was observed within the pteropodid bats. Out of the 37 species of plants in the study area, *C. sphinx* was found to depend on 35 species of plants, *R. leschenaultii* was found to depend on 27 species of plants and *P. giganteus* depended on 23 species of plants for their diet during different seasons of the year. Out of the 35 species of plants preferred by *C. sphinx*, 27 provide fruits, four provide leaves, one provides flowers, one provides leaves and flowers, one provides nectar and fruit and one provides flowers and fruit. Out of the 27 species of plants preferred by *R. leschenaultii*, 24 provide fruit, one provides flowers, one provides fruit and nectar, and one provides fruit and flowers. Of the 23 species of plants preferred by *P. giganteus*, 20 provide fruit, one provides leaves and fruit and two provide both flowers and fruit. In addition, *R. leschenaultii* and *P. giganteus* were observed feeding on toddy, a plant sap extract tapped from *Borassus flabellifer* by the local farmers.

Fruits preferred by bats at various stages of fruit development

A study was made on the fruits preferred by bats at various stages of fruit development in 11 species of plants (Table 2). Observations were conducted on the fruiting conditions of 11 species of plants preferred by

Table 1. Food providing plants for pteropodid bats and parts eaten by them

	Family	Species	Bat species		
			C. sphinx	*R. leschenaultii*	*P. giganteus*
1	Anacardiaceae	*Mangifera indica*	Fr	Fr	Fr
		Anacardium occidentale	Fr	Fr	Fr
		Lannea coromondelica	Fr	Fr	Fr
2	Annonaceae	*Annona squamosa*	Fr	Fr	Fr
		Polyalthia longifolia	Fr	Fr	Fr
		Polyalthia latifolia	Fr	Fr	Fr
		Annona reticulata	Fr	Fr	Fr
3	Bombacaceae	*Ceiba pentandra*	Fl	Fl	Fl/Fr
4	Caesalpiniaceae	*Tamarindus indica*	L	-	-
		Cassia fistula	L	-	-
5	Caricaceae	*Carica papaya*	Fr	Fr	Fr
6	Combretaceae	*Terminalia catappa*	Fr	Fr	Fr
7	Cucurbitaceae	*Coccinia grandis*	L/Fr	-	-
8	Elaeocarpaceae	*Muntingia calabura*	Fr	Fr	-
9	Guttiferae	*Calophyllum inophyllum*	Fr	Fr	Fr
10	Meliaceae	*Azadirachta indica*	Fr	Fr	Fr
11	Mimosaceae	*Pithecellobium dulce*	Fr	Fr	-
		Albizia lebbeck	L	-	-
		Prosopis juliflora	Fr	Fr	-
12	Moraceae	*Artocarpus integrifolia*	-	-	Fr
		Ficus reticulata	Fr	Fr	Fr
		Ficus benghalensis	Fr	Fr	Fr
		Ficus religiosa	Fr	Fr	Fr/L
		Morus alba	Fr	-	-
13	Moringaceae	*Moringa oleifera*	L	-	-
14	Musaceae	*Musa paradisiaca*	N/Fr	N/Fr	Fr
15	Myrtaceae	*Psidium guajava*	Fr	Fr	Fr
		Syzygium cumini	Fr	Fr	Fr
16	Palmae	*Borassus flabellifer*		Fr+	Fr+
17	Punicaceae	*Punica granatum*	Fr	Fr	Fr
18	Rutaceae	*Murraya koenigii*	Fr	-	-
19	Rhamnaceae	*Zizyphus jujuba*	Fr	-	-
20	Sapotaceae	*Bassia latifolia*	Fl/Fr	Fl/Fr	Fl/Fr
		Achras sapota	Fr	Fr	Fr
21	Solanaceae	*Solanum torvum*	Fr	-	-
22	Sterculiaceae	*Guazuma tomentosa*	Fr	Fr	-
23	Vitaceae	*Vitis vinifera*	Fr	Fr	-

the fruit eating bats in the study area. We observed that all the three pteropodid species, *C. sphinx*, *R. leschenaultii* and *P. giganteus* feeding on the ripe fruits of all the plant species (Table 2). *R. leschenaultii* and *C. sphinx* feed only on the unripe and ripe fruits and not on immature fruits. But in contrast, *P. giganteus* were found to feed on the immature fruits of *Mangifera indica* and they also prefer to feed on the unripe fruits of

Table 2. Preference of fruits by pteropodid bats on various developmental stages of fruits of various plant species

	Fruiting tree	Fruit conditioning stage	Bat species		
			C. sphinx	*R. leschenaultii*	*P. giganteus*
1	*Psidium guajava*	Immature	-	-	-
		Unripe	-	-	+
		Ripe	+	+	+
2	*Bassia latifolia*	Immature	-	-	+
		Unripe	-	-	+
		Ripe	+	-	+
3	*Ficus religiosa*	Immature	-	-	-
		Unripe	-	+	+
		Ripe	+	+	+
4	*Ficus benghalensis*	Immature	-	-	-
		Unripe	-	-	+
		Ripe	+	+	+
5	*Mangifera indica*	Immature	-	-	+
		Unripe	-	+	+
		Ripe	+	+	+
6	*Muntingia calabura*	Immature	-	-	-
		Unripe	+	-	-
		Ripe	+	+	-
7	*Syzygium cumini*	Immature	-	-	-
		Unripe	+	+	+
		Ripe	+	+	+
8	*Terminalia catappa*	Immature	-	-	-
		Unripe	+	+	+
		Ripe	+	+	+
9	*Polyalthia longifolia*	Immature	-	-	-
		Unripe	-	+	+
		Ripe	+	+	+
10	*Lannea coromondelica*	Immature	-	-	-
		Unripe	-	-	-
		Ripe	+	+	+
11	*Ceiba pentandra*	Immature	-	-	+
		UnRipe Ripe	-	-	-

Fr - fruit; Fl - flower; N - nectar; L - leaves; + - toddy; - not consumed/eaten

Psidium guajava, *Bassia latifolia*, *Ficus religiosa*, *F. benghalensis*, *M. indica*, *Syzygium cumini*, *Terminalia catappa* and *Polyalthia longifolia*. *C. sphinx* feed on the unripe fruits of *Muntingia calabura*, *S. cumini*, and *T. catappa*. Whereas, *R. leschenaultiii* feed on unripe fruits of *F. religiosa*, *S. cumini*, *T. catappa* and *P. longifolia*.

Seasonal availability of food of pteropodid bats

While studying the seasonal availability of food for pteropodid bats in the study area (Table 3), *C. sphinx* were found to enjoy the maximum food availability in all the months. *C. sphinx* had a higher frequency of food availability, between the months of March and September. *R.*

Table 3. Seasonal variation in the availablity of food for pteropodid bats

	Species name	Parts eaten by bats	Seasonal availability of food for bats											
			J	F	M	A	M	J	J	A	S	O	N	D
1	*Mangifera indica*	Fr			+	+	+	+						
2	*Anacardium occidentale*	Fr				+	+	+	+	+	+			
3	*Lannea coromondelica*	Fr					+	+				+	+	
4	*Annona squamosa*	Fr						+	+	+				
5	*Polyalthia lattifolia*	Fr							+	+	+	+		
6	*Polyalthia longifolia*	Fr		+				+	+	+				
7	*Annona reticulata*	Fr						+	+	+				
8	*Ceiba pentandra*	N/Fr		+	+	+/+	/+							
9	*Tamarindus indica*	L	+	+	+	+	+	+	+	+	+	+	+	+
10	*Cassia fistula*	L	+	+	+	+	+	+	+	+	+	+	+	+
11	*Carica papaya*	Fr	+	+	+	+	+	+	+	+	+	+	+	+
12	*Terminalia catappa*	Fr		+	+			+	+		+	+		
13	*Coccinia grandis*	Fr/L	+/+	+/+	+/+	/+	/+	/+	/+	/+	/+	/+	/+	/+
14	*Muntingia calabura*	Fr	+	+	+	+	+	+	+	+	+	+	+	+
15	*Calophyllum inophyllum*	Fr			+	+	+	+		+	+			
16	*Azadirachta indica*	Fr	+					+	+	+	+	+		+
17	*Pithecellobium dulce*	Fr		+	+	+	+	+	+					+
18	*Albizia labbeck*	L	+	+	+	+	+	+	+	+	+	+	+	+
19	*Prosobis juliflora*	Fr					+	+		+	+	+	+	+
20	*Atrocarpus integrifolia*	Fr					+	+	+	+	+			
21	*Ficus reticulata*	Fr				+	+				+	+	+	
22	*Ficus benghalensis*	Fr	+	+	+	+			+				+	+
23	*Ficus religiosa*	Fr/L	/+	/+	+/+	+/+	/+	+/+	+/+	+/+	/+	/+	/+	/+
24	*Morus alba*	Fr	+	+	+	+	+	+	+	+	+	+	+	+
25	*Moringa oleifera*	Fl/L	/+	/+	/+	/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+
26	*Musa paradisiaca*	Fr/N	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+
27	*Psidium guajava*	Fr/L	+/+	+/+	+/+	+/+	+/+	/+	/+	+/+	+/+	+/+	+/+	+/+
28	*Syzygium cumini*	Fr							+	+	+			
29	*Borassus flabellifer*	Fr/T			+/+	+/+	+/+	+/+						
30	*Punica granatum*	Fr/N		/+	/+	+/+	+/+							
31	*Murraya koenigii*	Fr							+	+		+	+	
32	*Zizyphus jujula*	Fr			+	+	+							
33	*Bassia latifolia*	Fl/Fr			+	+/	+/	+/+	/+	/+	/+			
34	*Achras sapota*	Fr	+	+	+	+	+	+	+	+	+	+	+	+
35	*Solanum torvum*	Fr			+	+	+	+	+	+				+
36	*Guazuma tomentosa*	Fr							+	+	+			
37	*Vitis vinifera*	Fr	+	+	+	+	+	+	+	+	+	+	+	+
Frequency		*C. sphinx*	18	22	27	29	29	30	29	30	26	22	20	20
		R. leschenaultii	11	13	16	17	21	22	18	20	17	12	11	10
		P. giganteus	8	11	16	19	18	20	16	15	14	10	9	8

Fr - fruit; Fl - flower; N - nectar; L - leaves; T - toddy; + - indicates availability

leschenaultii were found to have a higher frequency of food availability between the months of March and August. *P. giganteus* were found to have a moderate availability of food throughout the year and got maximum food availability between the months of March and August (Table 3).

Foraging patterns of pteropodid bats

A total of 16 observations (four observations each in different moon phases namely full moon, last quar-

ter, first quarter and new moon) were made to study the foraging patterns of pteropodid bats (Table 4). A bimodal foraging pattern was observed for *C. sphinx* and trimodal foraging pattern for *R. leschenaultii*. Foraging frequency of *C. sphinx* was found to be maximum (77.3%) between 2100hr and 2200hr and between 0200hr and 0300hr. A variation in the foraging pattern was observed in *C. sphinx* with reference to the different moon phases. During the full moon phase and the first quarter phase the activity was found to be minimal compared to the other two moon phases. *R. leschenaultii* was found to forage most (76.8%) with foraging bouts between 2100hr and 2200hr, and between 2300hr and 0000hr and later between 0300hr and 0400hr, and also show a variation in the foraging pattern similar to *C. sphinx* with regard to the moon phase. *P. giganteus* were found to have a variation in the foraging pattern and fed throughout the night; generally the foraging activity was not affected by the moon phase. Even though *P. giganteus* fed throughout the night, the maximum activity was observed between 1930hr and 2100hr, later between 0000hr and 0100hr and then between 0300hr and 0400hr.

Foraging flight heights of pteropodid bats

A total of 37 mist netting sampling nights were spent to observe the foraging and flight height of the pteropodid bats in the study area. Ten mist nets of large mesh size were used to capture *P. giganteus* and 15 and 12 mist netting sampling nights to capture *C. sphinx* and *R. leschenaultii* above and below the canopy level respectively. *C. sphinx*, *R. leschenaultii* and *P. giganteus* were found to have a profound difference in their foraging ability and foraging heights. *C. sphinx* were captured from a height of 1.5–21 m and capture was maximum only below the canopy level (> 3.5m). *R. leschenaultii* were captured from a height of 2–23.5 m and they were captured more at a height of 3.25–4.25 m. *P. giganteus* were observed foraging at a height of 8 ft above the ground level to the height of the foraging tree.

Even though *C. sphinx* was captured at a height of 1.5–21 m, a variation in capture heights with regard to the age and sex was observed. Of the 499 individuals of *C. sphinx* captured, 318 individuals were captured below the canopy level and 181 individuals above the canopy level. The capture rate of juvenile male (n = 46), male and female subadults of *C. sphinx* were found to be maximum above the canopy level than the adults (Table 5). Capture height between the juveniles, subadults and adults among the male and female bats of *C. sphinx* were not significantly different (Kruskal-Wallis Test, $p > 0.05$). Capture heights between the subadults of male and female bats of *C. sphinx* were significantly different (Mann-Whitney Test; $p < 0.05$).

In the case of *R. leschenaultii*, a total of 132 bats were captured. Out of this, 54 individuals were cap-

Table 4. Foraging patterns of pteropodid bats with reference to moon phase

Moon phase	Bat species	Time interval in hours and number of bats observed									
		1900 – 2000	2000 – 2100	2100 – 2200	2200 – 2300	2300 – 0000	0000 – 0100	0100 – 0200	0200 – 0300	0300 – 0400	0400 – 0500
First quarter	*C. sphinx*	63	88	110	100	81	73	70	93	62	41
	R. leschenaultii	21	32	33	41	63	52	43	41	51	34
	P. giganteus	32	49	31	29	31	33	39	26	29	33
Full moon	*C. sphinx*	59	42	89	61	53	41	39	69	32	23
	R. leschenaultii	19	23	27	26	59	31	29	31	49	17
	P. giganteus	27	41	21	24	19	21	38	24	23	31
Last Quarter	*C. sphinx*	77	93	123	98	83	57	42	79	32	27
	R. leschenaultii	23	29	37	34	69	31	33	41	58	27
	P. giganteus	31	44	29	23	28	31	46	21	23	29
New moon	*C. sphinx*	72	95	118	91	77	74	77	112	83	69
	R. leschenaultii	21	29	39	37	58	43	39	33	53	31
	P. giganteus	29	51	39	33	32	33	47	38	39	46

Table 5. Number of bats captured at above and below the canopy level

	Character	Sex and age of *C. sphinx*						N	Sex and age of *R. leschenaultii*						N
		Male			Female				Male			Female			
		J	SA	A	J	SA	A		J	SA	A	J	SA	A	
1	Below the canopy level	44	15	79	52	14	114	318	8	12	5	7	14	8	54
2	Above the canopy level	46	35	29	19	18	29	181	7	26	8	7	14	10	78

J - Juvenile; SA - Sub Adult; A - Adult

tured below the canopy level and 78 individuals were captured above the canopy level (> 3.5m). Of the 78 bats that were captured above the canopy level, 34 individuals belonged to the juvenile and subadult age groups and were observed to fly over a height of 10m, Whereas the capture of adults bats of *R. leschenaultii* was minimum above a height of 10m (Table 5) / strike the line.

P. giganteus were observed not to have any alteration in the foraging pattern and flight heights with regards to age and sex. *P. giganteus* were mainly found to be voracious feeders and fed throughout the night, foraging mostly at the height of the mid crown regions to the top regions of the fruiting tree. Usually *P. giganteus* were not observed to forage below 2.5m.

DISCUSSION

Frugivorous bats exhibit two patterns of foraging behaviour with reference to plants. They are 'sequential specialization' and 'individual generalization'. Sequential specialists use only one plant at a time but change food sources after several days or weeks (Colwell 1974). Individual generalists will visit several species of plants for nectar, pollen or fruit in one night. Observations made in our study corroborates with similar observations of Gardner (1977) that the individual-general pattern appears to be common among bats for whom fruits and flowers are major parts of the diet.

Foraging studies of pteropodids in Tirunelveli District revealed that 37 species of plants were observed to provide food for pteropodid bats. Bats in our study exhibited variations in their diet selection and preference. The diet preference in bats was mainly based on the morphological and palatable characters of the fruit (Corrlet 1996). Certain fruits may have a hard outer coat, which may be difficult to eat for certain small frugivores, certain fruiting trees may not facilitate the flying movements of some bats, but it may be preferred by others. Such a variation in the diet strategy may help the bats to avoid competition amongst themselves. Dietary selection in frugivores was documented by several authors (Fleming & Heithaus 1981; Tidemann & Nelson 1987). Fruits that are hard to carry to the night roost and some other fruits that are available above the foraging heights were normally less preferred by some bats, but bats that could overcome such obstacles preferred those fruits. Flying foxes are postulated to have a taste preference with reference to the selection of their food (Marshall 1983; Tidemann & Nelson 1987) which may be a reason for seasonal preference of fruits by these pteropodid bats. *P. giganteus* and *C. sphinx* prefer to feed on the leaves.

Folivory in *C. sphinx* (Bhat 1994) and the nutrient analysis in leaves fed by *C. sphinx* were well expressed (Ruby et al. 2000). *P. giganteus* were observed to feed only on the leaves of *Ficus religiosa*. Lowry (1989) refers to the phenomenon 'green leaf fractionation' whereby whole leaves are seldom consumed, but chewed and the whole liquid extract is consumed. A large amount of bolus of *F. religiosa* was collected and was observed to be a regular in the diet of *P. giganteus*. *P. giganteus* and *R. leschenaultii* were observed to drink 'toddy', which may be similar to that of the *P. mariannus* licking water from the surfaces of leaves as a supplement for moisture and nutrient requirements as observed by Wiles et al. (1991).

Observations on the diet selection in pteropodid bats revealed that they fed on unripe fruits, mature fruits and immature fruits. The main cause for this may be the low availability of resources and competition for other fruits. Certain orchard fruits were observed to be fed on in immature and unripe stages, this may be due to the nature of palatablity. Wiles & Fu-

jita (1992) reported that the flying foxes in the Pacific Islands fed on the cultivated plants at stages of fruit maturity. Jacobsen & DuPlessis (1976) reported that *Rousettus aegyptiacus* fed on green figs that were hard to crush at times, when there was a scarcity of availability of food.

On studying the seasonal availability of food for the pteropodid bats, *C. sphinx* were observed enjoying a wide variety of food availability. It may have been because of their flexibility in food selection or also of opportunistic food choice. *P. giganteus* were observed to have lesser fruit choice and availability throughout the year. Most of the *Pteropus* species were observed to commute longer distances for their foraging activity (Nelson 1965). Similarly *P. giganteus* were also observed to be long distance foragers (Goyal et al. 1993) to fulfill their dietary requirements and also makes it an opportunistic feeder. On studying the diet availability for bats in various months of the year, the maximum availability of food was during their breeding periods and bats switched over to different food items according to their availability. The reproductive periods of bats are ultimately determined by food availability (Marshall 1985). The timing of reproductive events among plants (flowering and fruiting) may influence the bat's reproductive cycles, foraging patterns and the intensity of competition for food resources among bat species (Heithaus et al. 1975).

In case of plant-visiting bats, resource abundance and distribution pattern appear to significantly influence foraging group size. This point was well illustrated by the behaviour of *Phyllostomus discolor* (Heithaus et al. 1974; Sazima & Sazima 1978). The feeding group size of *P. discolor* declines as the number of flowers per plant declines (Fleming 1982). A similar pattern of foraging activity was also observed in *R. leschenaultii* and *P. giganteus*. Howell (1979) argues that the main advantage of flock foraging was that it increases individual foraging efficiency on patchily distributed flowers. Species like *Artibeus jamaicensis* and *Phyllostomus hastatus* fly in groups, but both are also solitary foragers (Goodwin & Greenhall 1961).

C. sphinx was observed to show a bimodal foraging pattern, while *R. leschenaultiii* showed a trimodal foraging pattern. Bats probably exemplify various modes of foraging patterns, the first peak is at the beginning of the foraging activity and the second peak towards the end (Erkert 1982). Unlike *C. sphinx* and *R. leschenaultiii*, *P. giganteus* were observed to be voracious feeders, feeding throughout its foraging activity.

The foraging patterns in bats were observed to be affected by the moonlight and environmental factors (Kunz 1982). The pattern of foraging in *C. sphinx* and *R. leschenaultii* altered at a greater rate depending on the moon phase. *C. sphinx* showed a decreased pattern in its foraging activity during full moon (Elangovan & Marimuthu 2001; Singaravelan & Marimuthu 2001). The reason for this may be the that the bats protect themselves from other predators (Nair et al. 1998).

A variation in the flight height was observed in *C. sphinx* and *R. leschenaultii*. *R. leschenaultii* was observed to have a higher foraging echelon than that of the *C. sphinx*. In our study *C. sphinx* foraged normally at the canopy level, *R. leschenaultii* foraged at upper canopy levels and *P. giganteus* above the crown area at a greater rate. The variation in foraging height of *R. leschenaultiii* may be mainly determined by the wing loading and the aspect ratio (Fenton et al. 1987; Elangovan et al. 2004). The variation in the foraging height also helps the bats to have different foraging strategies, flight mode and food preferences. This strategy helps the bats to utilize the resources to a greater extent. In our study, apart from the regular foraging heights, bats were also observed to engage in foraging guilds at various heights; such conditions were observed to exist only when the fruit availability was low. The observation made by us is similar to that by Cosson (1995), who studied the pteropodid bat flight activity level under forest canopy in southern Cameroon and reported that small frugivores feed on the understorey low lying fruits whereas large frugivores feed on the fruits in the upper canopy level.

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