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Feeding Ecology of *Trachypithecus pileatus* in India

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Abstract We observed a group of capped langurs for 12 mo in the Pakhui Wildlife Sanctuary, Arunachal Pradesh, India. We recorded the time of feeding on different food plant species, food categories, and the feeding heights of monkeys in trees. Capped langurs spent 68% of their feeding time on leaves, 16% on flowers, and 16% on fruits. Feeding on leaves was consistently high ($p<0.01$) during the year, with the highest feeding in May (85%) and the lowest in January (47%). The seasonal difference in feeding on leaves is significant ($p<0.05$): it was higher in summer and during monsoon. The feeding time on flowers was maximal (35%) in March and that on fruits and seeds was minimal (38%) in January. Langurs ate 52 plant species throughout the year. The largest number of plants (6) were species of Moraceae, and langurs spent more feeding time (20%) on them alone. The number of plants eaten per month varied significantly ($p<0.05$). Langurs ate *Gmelina arborea, Albizzia lucida, Ficus glomereta*, and *Makania micrantha* throughout the year. They spent 44% of their feeding time in terminal canopies and their average feeding height was 30–35 m. This is the first study to examine the feeding ecology of capped langurs and provides baseline data for the species.

Keywords Capped langur · feeding time · food categories · food plants · Pakhui Wildlife Sanctuary

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Introduction

Capped langurs (*Trachypithecus pileatus*) are indigenous to northeast India (Srivastava 1999), with a global distribution that is restricted to Bangladesh, northwestern Myanmar, Bhutan, and Southern China (Ahsan 1994; Khan and Ahsan 1986; Roonwal and Mohnot 1977; Srivastava 1999; Zhang *et al*. 1981). They are largely folivorous colobines (Choudhury 1989; Stanford 1991); however, studies on their food selection, preference, dietary composition, and foraging behavior are very sparse. Except for a study in Bangladesh by Stanford (1991) and the preliminary feeding observations on them that Choudhury (1989) and Gupta (1998) recorded in India, there was no other published study on feeding, food selection, preference of food plants, and dietary composition of capped langurs. We report the dietary items consumed by capped langurs, the time they spent feeding on each plant species, and their location in the canopy when feeding. The information could be useful to management of the habitat of capped langurs.

Materials and Methods

Study Site

We conducted the study at the Pakhui Wildlife Sanctuary, located between 92°7.5′–92° 22′E and 26° 3.7′–27°16.2′N, which covers a geographical area of 861.95 km^2 in the East Kameng District of Arunachal Pradesh. The sanctuary is naturally surrounded by rivers on 3 sides and shares a common boundary with Nameri National Park, in Assam on its fourth side. It receives an average annual rainfall of 2545 mm. The mean annual maximum temperature is 28°C and the minimum is 19°C. Average relative humidity is 84%. The altitudinal variation ranges from 100 m to 2040 m above sea level. The sanctuary harbors different types of vegetation, viz., tropical evergreen forests, tropical semi-evergreen forests, and subtropical forests (Champion and Seth 1968). There are 234 woody species of flowering plants (angiosperms) in the lowland areas of the sanctuary. Several rare and endangered species of flora and fauna inhabit the sanctuary, including 4 species of primates: *Macaca mulatta, M. assamensis, Trachypithecus pileatus*, and *Nycticebus bengalensis*.

Study Group

We chose a 1 male-multifemale group of capped langurs from the wild population for collection of data on different aspects of food and feeding during October 2001 to September 2002. The composition of the study group was 1 adult male, 5 adult females, 1 subadult, and 1 infant. The group was habituated for the presence of humans.

We followed them from 0600 h to 1700 h per day for 14 consecutive days during the first 2 wk of every mo. We recorded the observations in 2 sessions, viz., morning (0600–1130 h) and afternoon (1130–1700 h) on different focal individuals in different sessions (Bartlett 1999). We rotated the focal individual among the adult members to ensure representation of all members. We divided the observation period

into 3 seasons: winter (November–February), summer (March–May), and monsoon (June–October).

We recorded observations every 5 min via focal individual sampling (Altmann 1974). Thus we recorded 12 entries on the focal individual in an hour. We recorded time the focal individual spent on each food plant and the parts eaten along with the time spent at different feeding sites. We categorized plant parts the focal individual ate as young leaves, mature leaves, flowers, flower buds, fruits, seeds, and others including gum, bark, etc. We combined related plant parts such as young and mature leaves, flowers and flower buds, and fruits and seeds into 3 major food categories.

We recorded tree height and feeding height of the individual in trees via clinometers. We horizontally stratified trees into 7 zones of 5 m each up to 35 m. The feeding area in the tree was its canopy. We further divided the feeding area into 5 feeding sites: top canopy (TC), middle canopy (MC), terminal canopy (T), bottom canopy (BC), and under canopy (UC). We recorded the time spent at each feeding site.

We estimated time spent in feeding on different food items in a day per the formula of Gupta and Kumar (1994) for *Presbytes phyrae* in India.

$$T_a = \frac{N_a \times 100}{N}$$

wherein T_a=% time spent on activity a, N_a=number of records with activity a, and N=total number of records for the day. We used analysis of variance (ANOVA) to compare feeding time on food categories and number of food plants eaten monthly and seasonally (Simpson *et al*. 1960). We used the daily mean of the feeding time on food categories and number of food plants eaten to calculate the monthly mean (n=12), and used the monthly mean to calculate the seasonal mean (n=3).

Results

Food Categories and Time Spent Feeding on Them

We combined the average feeding time on each food category in each month to represent the annual feeding on food categories. Capped langurs spent 68% (±12.1%) of their annual feeding time eating leaves, including young (57%) and mature (6%) ones, and petioles (4%). Young leaves are the dominant food category in the diet. The time spent on fruits and seeds was 16% (± 10.2%), and that on flowers and their buds was 16% (± 9.0%) of the total feeding time. The dispersion pattern of food categories indicates that feeding on leaves is relatively more consistent than that on other categories of food on an annual basis.

The monthly feeding time on different food categories is in Fig. 1. Feeding time on leaves was high in all months; however, the variation in feeding time across months is significant (F=7.26, df=11, p<0.01). The minimal feeding time occurred in January and the maximal was in May. Langurs spent ≥70% of feeding time on leaves each month from April to September. The monthly variation in time feeding on flowers and flower buds is high (F=4.95, df=11, p<0.05); feeding was maximal in February and March, followed by November and December, and less in the remaining months. Feeding on fruits and seeds occurred in all months; the maximal

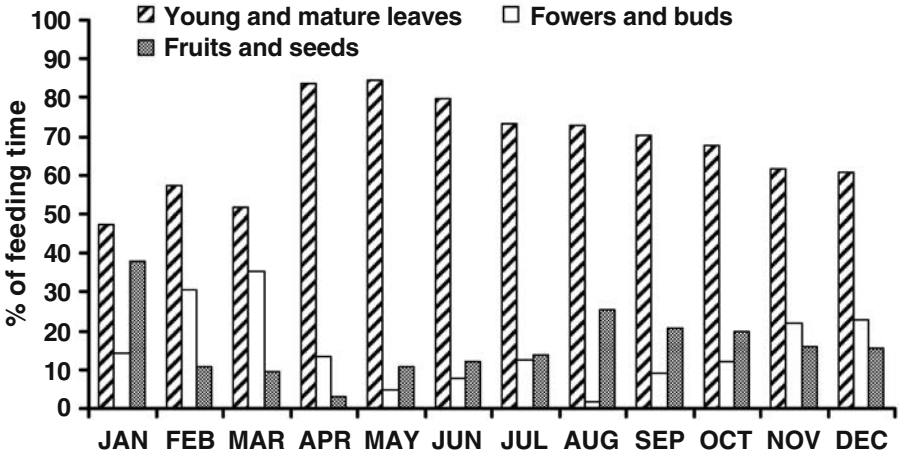

Fig. 1 Monthly variation in food categories in the diet and time spent (%) on feeding.

feeding was in January and the minimal in April (Fig. 1). Feeding on other food items such as bark and gum was highly inconsistent. When we reorganized the monthly feeding time on different food categories on a seasonal basis, leaves were predominate over other food categories in all seasons: 57% in winter and 73% in summer and in the monsoon season. The time feeding on leaves in different seasons is significant (F= 3.49, df=2, p<0.05), whereas other food categories did not vary seasonally.

Food Plants Species Consumed

Food plant species, parts of food plants, and average feeding time (%) on them is in Table I. Capped langurs ate 52 food plant species that belong to 30 families. 90% of them were trees, 6% were climbers, 2% were aquatic plants, and 2% were bamboo. The 6 most frequently consumed plant species are Moraceae; 4 are Mileaceae; and 3 each are Anacardiaceae, Euphorbiaceae, Lauraceae, and Myrtacea.Langurs spent 20% of feeding time on 6 plants, viz., *Ficus glomerata, F. bengalensis, F. religiosa, F. lamponga, Morus laevigata*, and *Artrocarpus chaplasa* (Moraceae); 19% on *Gmelina arborea* (Verbenaceae); 12% on 2 species, *Albizia lucida* and *A. procera* (Mimosaceae); and 9% on the climber *Makania micrantha*. Of all the food plant species, the subjects utilized 73% (n=38) of 1 type of food item at any given time, and 27% (n=14) on >1 type of food item (Table I). Of the 52 food plant species, subjects foraged 60% for fruits and seeds, 48% for young and mature leaves, 15% flowers and buds, and 4% for other food items (Table I).

Number of Food Plant Species Eaten

The number of food plant species eaten in a full day was not consistent; it varied from 4 to 11 (mean = 7.1 ± 1.7). The number of plant species eaten each month ranged form 16 to 28 (mean = 20 ± 3.4); they ate a maximum of plant species (28) in September and a minimum (16) in March (Table II). The variation in the number

Table I Food plants, plant parts eaten, and average feeding time (%) on them

Sl. No.	Scientific name	Family	Average. feeding time (%)	Part eaten	Habit
1	*Gmelina arborea* Roxb.	Verbenaceae	18.65	YL, ML	T
2	*Albizia lucida* Benth.	Mimosaceae	12.13	YL, ML, F	T
3	*Ficus glomerata* Roxb.	Moraceae	9.24	YL	T
4	*Makania micrantha* H.B.& K.	Compositae	8.78	YL, ML	CL
5	*Morus laevigata* Wall.	Moraceae	8.32	YL, ML	T
6	*Bombax ceiba* Linn.	Malvaceae	4.22	FL, FB	T
7	*Kydia calycina* Roxb.	Malvaceae	3.94	ML, FL	\T
8	*Euodia glabrifolia* (Champ.) Balakr.	Rutaceae	3.61	F,	T
9	*Duranta pulmeri* Jacq. Var.	Verbenaceae	2.53	YL	CL
10	*Elaeocarpus obtusus* Blume.	Elaeocarpaceae	2.49	YL	T
11	*Cassia nodosa* Buch.-Ham.	Caesalpinaceae	2.41	F	T
12	*Sterculia villosa* Roxb.	Sterculiaceae	1.91	FL, SE	T
13	*Litsea monopetala* (Roxb.) Pers	Lauraceae	1.83	YL, FL	T
14	*Sapium baccatum* Roxb.	Euphorbiaceae	1.40	F	T
15	*Dillenia indica* Linn.	Dilleniaceae	1.38	FL, F	T
16	*Persea globosa* (A. Das) Kosterm	Lauraceae	1.10	F	T
17	*Toona ciliata* M. Roem.	Meliaceae	1.18	YL	T
18	*Anthocephalus cadamba* (Roxb.) Miq.	Rubiaceae	1.15	F	T
19	*Ficus bengalensis* Linn.	Moraceae	1.00	FB	T
20	*Syzygium malaccansis* L.	Myrtaceae	0.95	F	T
21	*Chukrasia tabularis* A. Juss.	Meliaceae	0.91	YL	T
22	*Amoora wallichii* King.	Meliaceae	0.90	YL	T
23	*Cinnamomum glanduliferum* Meissm.	Lauraceae	0.83	YL	T
24	*Syzygium formosum* (Wall.) Masam.	Mytraceae	0.76	F	T
25	*Bischofia javanica* Blume.	Euphorbiaceae	0.71	F, YL	T
26	*Alstonia scholaris* Linn.	Apocynaceae	0.70	F	T
27	*Aesculus assamica* Griffith	Anacardiaceae	0.61	YL	T
28	*Castanopsis armata* Spach.	Fagaceae	0.59	YL	T
29	*Artocarpus chaplasha* Roxb.	Moraceae	0.52	F	T
30	*Bauhinia purpurea* Linn.	Leguminosae	0.50	FL, YL, F	T
31	*Altingia excelsa* Noron.	Hamamelidacea	0.38	F	T
32	*Ficus religiosa* Linn.	Moraceae	0.37	F	T
33	*Spondias axillaris* Roxb.	Anacardiaceae	0.33	F	T
34	*Dendrocalamus hamiltonii* Nees & Arn	Bambuseae	0.31	Shoot	B
35	*Ficus lamponga* Miq.	Moraceae	0.31	YL	T
36	*Shorea assamica Dyer.*	Dipterocapaceae	0.31	SE	T
37	*Stereospermum chelonoides* DC.	Bignoniaceae	0.28	SE	T
38	*Vitis planicaulis* Hook.f.	Vitaceae	0.24	YL, SE	L
39	*Castanopsisindica* A. DC.	Fagaceae	0.24	SE	T
40	*Albizia procera* (Roxb.) Benth.	Mimosaceae	0.22	SE	T
41	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	0.21	YL	T
42	*Piper pedicellatum*	Piperaceae	0.20	F, ML, YL	CL
43	*Nymphaea alba*	Nympheaceae	0.20	YL, ML, FL	AP
44	*Horsfieldia kingii* (Hook. f.) Warb.	Myristicaceae	0.19	YL, F	T
45	*Bridelia retusa* Spreng.	Euphorbiaceae	0.18	SE	T
46	*Dysoxylum binectariferum* Hook.f.	Meliaceae	0.18	F	T
47	*Spondias pinnata* Kurz.	Anacardiaceae	0.18	F, YL	T
48	*Ziziphus rugosa Lamk.*	Rhamnaceae	0.14	F	T
49	*Syzygium syzygioides*	Mytraceae	0.13	YL	T
50	*Elaeocarpus floribundus* Blume.	Elaeocarpaceae	0.08	F, Bark	T
51	*Terminalia chebula* Retz.	Combretaceae	0.04	F	T
52	*Lagerstroemia flos-reginae* Retz.	Lythraceae	0.04	F	T

YL = Young leaves; ML = mature leaves; SE = seed; F = fruit; FL = flower; FB = flower bud; T = trees; CL = climber; B = bamboo; L = lianas; AP = aquatic plants.

Table II Monthly variation in feeding time (%) on each plant species

Scientific name	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Gmelina arborea	14.6	4.4	2.4	3.9	6.6	20.0	30.2	34.6	32.5	30.5	31.4	12.8
Albizia lucida	18.2	3.8	4.1	25.7	3.2	12.3	3.5	12.0	15.9	16.8	14.3	15.8
Ficus glomerata	8.4	21.0	21.9	13.4	23.5	6.9	6.2	2.3	2.7	2.3	2.2	0.3
Makania micrantha	16.1	15.0	10.2	19.6	6.3	3.5	3.3	6.3	5.5	4.2	4.2	11.4
Morus laevigata	–	–	–	–	3.3	21.5	29.3	12.8	9.9	10.9	9.8	2.4
Bombax ceiba	1.8	–	1.8	1.9	9.1	9.7	6.3	–	3.9	–	1.5	14.6
Kydia calycina	14.6	19.0	13.6	–	–	–	–	–	–	–	–	–
Euodia glabrifolia	1.6	3.7	4.7	2.5	7.0	–	5.2	7.5	8.8	1.3	1.1	–
Duranta pulmeri	0.7	5.0	4.4	6.1	3.5	1.4	–	–	–	–	1.9	7.4
Elaeocarpus obtusus	–	–	–	–	3.3	2.1	0.9	3.0	1.3	10.0	8.9	0.5
Cassia nodosa	–	6.6	6.9	7.5	1.4	0.9	–	–	2.9	2.0	–	0.8
Sterculia villosa	–	–	–	–	10.4	7.6	2.4	1.9	–	0.7	–	–
Litsea monopetala	–	–	–	4.1	7.4	–	2.1	2.8	1.6	1.6	2.5	–
Sapium baccatum	–	–	–	–	–	–	–	1.0	7.5	4.3	4.0	–
Dillenia indica	3.8	–	0.8	3.9	–	0.6	–	–	0.1	1.2	4.5	1.7
Persea globosa	–	–	0.4	–	0.9	–	1.2	0.7	2.9	3.3	3.5	0.3
Toona ciliate	2.9	1.8	3.3	1.1	–	–	1.6	–	1.2	1.7	0.6	–
Anthocephalus cadamba	4.4	2.7	0.6	2.8	–	–	–	–	0.6	–	–	2.6
Ficus bengalensis	0.9	1.5	8.4	1.3	–	–	–	–	–	–	–	–
Syzygium malaccansis	–	–	0.6	3.4	0.3	–	–	4.9	–	2.3	–	–
Chukrasia tabularis	1.0	1.6	0.2	–	1.5	2.0	3.2	0.9	0.4	–	–	–
Cinnamomum glanduliferum	–	–	–	–	5.4	–	2.2	–	0.4	1.6	0.3	–
Syzygium formosum	–	2.7	2.5	0.7	1.1	–	–	–	–	–	–	2.2
Bischofia javanica	–	2.7	1.4		2.0	1.7	–	–	–	–	–	0.6
Alstonia scholaris	–	–	–	–	–	–	–	–	–	–	–	8.4
Aesculus assamica	1.3	1.3	0.2	1.7	0.5	–	–	2.3	–	–	–	–
Castanopsis armata	–	–	–	–	–	–	–	1.4	–	–	2.3	3.4
Artocarpus chaplasha	2.7	0.7	–	–	–	–	0.4	–	0.1	0.7	–	1.6
Bauhinia purpurea	–	–	–	–	–	6.0	–	–	–	–	–	–
Altingia excelsa	–	–	–	–	–	–	–	–	–	–	4.6	–
Ficus religiosa	–	–	–	–	–	–	–	3.3	–	1.2	–	–
Spondias axillaries	–	–	–	–	–	4.0	–	–	–		–	–
Dendrocalamus hamiltonii	–	–	–	–	–	–	–	–	–	1.8	2.0	–
Ficus lamponga	–	–	–	–	–	0.2	1.4	2.1	–	–	–	–
Shorea assamica	–	–	–	–	–	–		–	–	–	1.2	2.5
Stereospermum chelonoides	–	–	–	–	–	–	2.1	–	1.3	–	–	–
Vitis planicaulis	1.3	0.7	0.8	–	–	–	–	–	–	–	–	–
Castanopsisindica	2.9	–	–	–	–	–	–	–	–	–	–	–
Albizia procera	–	–	–	0.7	0.6	–	–	0.5	–	–	–	0.9
Terminalia bellirica	–	–	–	–	–	–	–	–	–	–	1.2	1.3
Piper pedicellatum	–	–	–	–	–	–	–	–	–	1.4	–	0.9
Nymphaea alba	–	–	–	–	–	–	–	–	–	–	–	2.4
Horsfieldia kingii	–	–	–	–		–	–	–	–	–	–	2.3
Bridelia retusa	–	–	0.8	–	0.4	–	–	–	0.6	–	0.3	–
Dysoxylum binectariferum	–	–	–	–	–	–	–	–	–	–	–	2.1
Spondias pinnata	–	–	–	–	–	–	–	–	–	–	–	2.2
Ziziphus rugosa	–	–	–	–	–	–	–	–	–	–	1.4	0.3
Syzygium syzygioides	–	0.8	0.8	–	–	–	–	–	–	–	–	–
Elaeocarpus floribundus	–	–	–	1.0	–	–	–	–	–	–	–	–
Terminalia chebula	–	–	–	–	0.5	–	–	–	–	–	–	–
Lagerstroemia flos-reginae	–	–	–	–	–	–	–	–	–	–	–	0.5

of plant species eaten each month is significant (F=6.2, df=11, p<0.05). The number of food plants species used in 3 seasons ranged from 30 to 46 (mean=36.0± 8.7); however, the seasonal variation in plants eaten is insignificant (F=1.53, df=2, p>0.1). Of the 52 food plants species, capped langurs ate 4 species viz., *Gmelina arborea, Albizzia lucida, Makania micrantha*, and *Ficus glomerata,* throughout the year, *Euodia glabrifolia* for 10 mo; *Bombax ceiba* for 9 mo; *Morus laevigata, Duranta pulmeri, Elaeocarpus obtusus, Cassia nodosa, Dillenia indica, Persea globosa, Toona ciliate, Chukrasia tabularis* for 8 mo; *Litsea monopetala* for 7 mo in a year; and other plant species less often (Table II).

Feeding Sites

Capped langurs spent 44% of their annual feeding time in the terminal canopy of trees, 24% in the top canopy, 18% in the middle canopy, 6% in the bottom canopy, and 3% in the under canopy, with 5% of total feeding on the ground. The time spent at different feeding sites in a food tree in each month is in Fig. 2. The variation in feeding time on different sites strikingly indicates that the langur's feeding time in the terminal canopy was greater from February to October than in other months.

Discussion

The capped langurs consumed the variety of food items. The maximal time they fed on young leaves confirms a folivorous habit for the species. Fifty-two food plant species provided a broad dietary spectrum for Pakhui capped langurs. Newton (1992), Sunderraj and Johnsigh (1993), and Gupta and Chivers (2000) also reported nearly equal numbers of plant species in the diets of *Presbytis entellus, Trachypithecus johnii*, and *T. geei* in India. Stanford (1991) reported 35 food plants

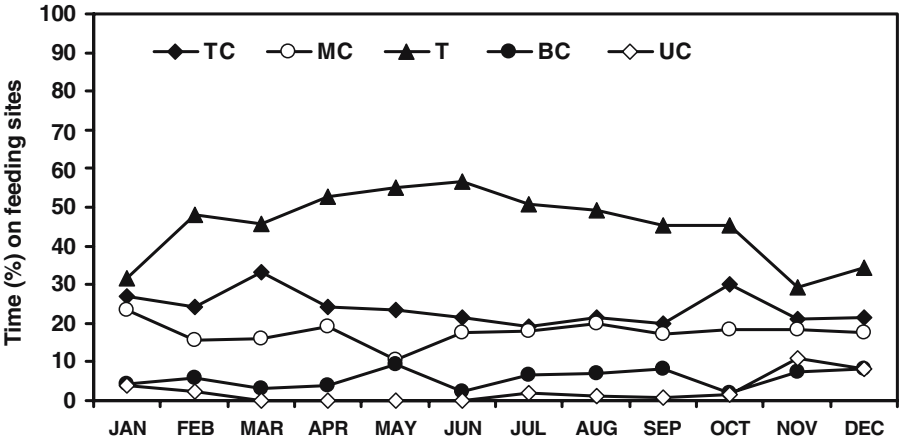

Fig. 2 Monthly variation in feeding time (%) in different feeding sites on the food plants. TC=Top canopy; MC=middle canopy; T=terminal canopy; UC=under canopy; BC=bottom canopy.

in the diet of capped langurs in Bangladesh. Floristic composition of the habitat appears to determine the spectrum of food plant species in their diets.

The food plants, phenological stages of the plants, and type of habitats determine the proportion of food items in their diet. Stanford (1992) reported the dominance of mature leaves in the diet during winter months; in May to September langurs ate mainly fruits. The proportion of foliage in the overall diet of capped langurs (67%) is comparable with that of other Colobinae, viz. 72% for *Procolobus pennantii* (Struhsaker 1975), 77% for *P. hoseii* (Mitchell 1994), and 70% for *Trachypithecus geei* (Biswas *et al*. 1996). Capped langurs at Pakhui Wildlife Sanctuary consumed more young leaves (57%) than other Asian colobines did. Consumption of young leaves probably meets the requirement of essential nutrients and protein because they contain a high percentage of crude protein (Krishnamani 1994; Kumar and Solanki 2004; Struhsaker 1975); Davies (1984). Waterman *et al*. (1988) reported that leaves also maintain the foregut environment where digestion of plant food items occurs. Abundance of young leaves and petioles in the diet of colobines maintains a high ratio of cell sap (contents) to cell wall in the items and their high digestibility (Oates *et al*. 1980). Availability of leaves, especially young ones, indicates the quality of habitat that can support the langur population.

Flowers and flower buds and fruits and seeds are important constituents of langur diets and the phenological stage of food plant species influences their availability. Solanki *et al.* (2007) conducted a study on breeding activities of capped langurs and related the months of intensive feeding of flowers, fruits, and seeds (Fig. 1) with the period when they reproduce, which may be energy demanding. Oates (1988) suggested that variation in seed eating is apparently due to high availability of seeds and low abundance of young leaves as the dry season progresses. Waterman *et al*. (1988) indicated that seeds are high-quality food items, and their nutrient content and digestibility are usually relatively high. Thus in the dry season when leaves are inadequate, langurs sustain themselves on flowers, fruits, and seeds from *Bombax ceiba, Sterculia villosa, Kydia calycina,* and *Dillenia indica*.

The vertical structure of the plant community provides a physical framework in which many forms of animal life are adapted. Increase in vertical structure means more resources and living space (Smith and Smith 2000). Capped langurs fed most of the time in the thicker terminal canopy (edge of canopy), possibly because of the presence of young foliage. Second, the sanctuary harbors natural predators like tigers and leopards and also local tribes frequently hunt them for various purposes (Solanki 2005). Thus in feeding in the terminal canopy, langurs gain safer height from predators. The langurs restricted their daily movement but changed feeding ground frequently for better food quality.

Our data could serve as a management tool to increase the base of existing food resources by planting food species in the degraded land around the sanctuary. Conserving plants of Moraceae may be a useful measure; langurs spent 20% of feeding time on them. Food plant species such as *Gmelina arborea, Ficus glomerata, Albizzia lucida, Morus levigata, Makania micrantha, Kedia calycina, Bombax ceiba*, and *Sterculia villosa* are the most important food resources. They may ensure the availability of young leaves and other foods, and a healthy population of langurs could be maintained. Plants having low dominance (Solanki 2005) and moderately high feeding time on them such as *Elaeocarpus obtusus,*

Litsea monopetala, Sapium baccatum, and *Euodia glabrifolia* require more attention for their conservation. Thus habitat restoration would facilitate the conservation of capped langurs and other primates on a long-term basis.

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