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Winter food selection and diet composition of capped langur (*Trachypithecus pileatus*) in Arunachal Pradesh, India

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Abstract: The food selection, preference, and diet composition of capped langur (*Trachypithecus pileatus*) were studied during two winter seasons. Capped langur spent 36.8% of their time in feeding during winter months. Young leaves (42%), flowers (22%), fruits (17%), mature leaves (15%), and seeds (3%) constituted the major food items. Leaves contributed 57% in the diet of langur. *T. pileatus* derived food from 43 plant species. Of these, 33 were sources of leaves, 15 were sources of fruits, 10 were sources of flowers and 6 were sources of seeds. The average number of plant species eaten each month during the study period was 19.6. Plants in the Moraceae family were widely consumed. Capped langur often ate young leaves of *Ficus glomerata* and *Kydia calycina*. Young leaves of *Mikania micrantha* also contributed to the diet of the langurs.

Resumen: Durante dos estaciones invernales se estudió la selección de alimento, las preferencias y la composición de la dieta del langur encapotado (*Trachypithecus pileatus*). El langur encapotado dedicó 36.8% de su tiempo para alimentarse durante el periodo invernal. Las hojas jóvenes (42%); las flores (22%), los frutos (17%), las hojas maduras (15%), y las semillas (3%) constituyeron los productos alimenticios principales. Las hoja constituyeron 57% de la dieta del langur encapotado. *T. pileatus* obtuvo comida a partir de 43 especies de plantas. De éstas, 33 fueron fuente de hojas, 5 fuente de frutos, 10 fuente de flores y 6 fuente de semillas. En promedio, cada mes durante el periodo de estudio fueron consumidas 19.6 especies vegetales. Las plantas de la familia Moraceae fueron consumidas ampliamente. Con frecuencia el langur encapotado comió hojas jóvenes de *Ficus glomerata* y *Kydia calycina*. Las hojas jóvenes de *Mikania micrantha* también contribuyeron a la dieta de los langures encapotados.

Resumo: A selecção alimentar, preferência e composição da dieta do macaco langur (*Trachypithecus pileatus*) foi estudada duas estações de inverno. O macaco langur despende 36.8% do seu tempo na alimentação durante os meses de inverno. Os maiores itens da dieta foram constituídos pos folhas jovens (42%), frutos (17%), folhas maduras (15%), e sementes (3%). As folhas constribuíram 57% para a dieta do macaco. O *T. Pileatus* retirou a sua alimentação de 43 espécies de plantas. Destas, 33 foram fonte de folhas. 15 fornecedoras de frutos, 10 fonte de flores e 6 fonte de sementes. O número médio de plantas comidas em cada mês durante o período de estudo foi de 19,6. As plantas da família das Moraceae foram largamente consumidas. O macaco langur frequentemente comeu folhas de *Ficus glomerata* e *Kydia calycina*. As folhas novas de *Mikania micrantha* também contribuíram para a dieta dos macacos langur.

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Key words: Diet composition, feeding behaviour, food preference, moraceae, Pakhui Wildlife Sanctuary, *Trachypithecus pileatus*.

Introduction

Primates respond to variations in seasonal resource abundance by changing their diet composition with alternative plant species (Remis 1997; Tutin *et al*. 1997), by increasing feeding time (Overdorff 1996) and/or changing pattern of other activities like rest, travel, etc. (Chapman 1988 a). The physiological status such as reproduction and lactation, and sex category of an animal also influence its food selection and feeding behaviour (Altmann 1980; Clutton-Brock *et al*. 1989; Garber 1987). Furthermore, the characteristics of habitat, including its eco-climatic conditions, exert a profound influence on all aspects of feeding ecology (Hladik 1975; Marsh 1986; Stanford 1991 a; Wiens 1989). Winter is presumably the most ecologically stressful season due to low temperatures and limited local food resources in a tropical country like India. Winter is also the period of mating activities for Capped langur (Solanki *et al*. 2007). Therefore, winter is the period for high-energy demand, particularly, due to breeding activities (Reynolds & Gross 1990). How does the animal respond in such condition? No information on these aspects is available for the Indian population of *Trachypithecus pileatus*. The present study was carried out to understand the composition of diet and selection of food and food plants in winter season by the capped langur. The knowledge on winter diet of *T. pileatus* will help in habitat management and conservation of this endangered primate species.

Materials and methods

We carried out this study in Pakhui Wildlife Sanctuary (861.95 km^2), located between 92º36'-93º09' E and 26º54' - 27º16' N in East Kameng district of western Arunachal Pradesh, India. The study area is bordered by the Kameng river in the northwest and the Pakke river in the east. The southern side of the study area has a contiguous boundary with the Nameri National park of Assam. The forests are multi-storied, general vegetation is tropical semi-evergreen (Champion & Seth 1968), rich in epiphytic flora and woody lianas. The altitude of the sanctuary ranges from 200 m to over 2000 m above sea level. The climate of the area is tropical to subtropical; cold weather prevails from October to February. Winter season is characterized by low temperature, rainfall and humidity as compared to other seasons. October and November are relatively dry months. Minimum temperature during the study period was 12ºC in January and maximum was 32ºC in October (Fig. 1).

The capped langur (*Trachypithecus pileatus*), an endangered primate species of the sub-family Colobinae, lives in relatively small groups. We studied one unimale - multifemales group of *T. pileatus* in Pakhui Wildlife Sanctuary during two consecutive winter seasons (October to February for the years 2001-2002 and 2002-2003). A group of 8 individuals, composed of 1 adult male, 4 adult females, 1 sub-adult female, and 2 juvenile, was selected for the study.

We collected data through *Ad libitum* sampling technique based on a focal individual with five minutes interval as described by Altmann (1974). The focal individual was rotated among the adults every day. The selected group was followed and observed for 10 consecutive days in each month continuously from 06:00 h to 17:00 h. Feeding time spent by the focal animal on each food plant and the parts eaten were recorded.

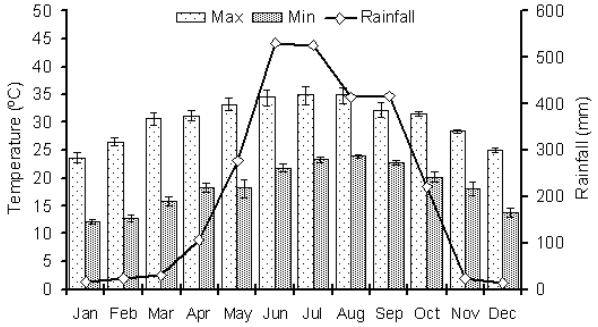

Fig 1. Climatic pattern of study area.

Plant parts eaten by the animal were classed as young leaves, mature leaves, flowers (including flower buds), fruits, seeds and others. The plant parts eaten were combined into major food categories such as leaves, flowers, fruits and seeds. Phenological data for the food plants were collected to assess the availability of food categories to the langurs during the study period (Fig. 2). Percentage feeding time on different food items was calculated as described by Gupta & Kumar (1994). Food diversity and food preference were calculated on the basis of feeding time on a plant species and part of the particular plant eaten as per procedure given by Sussman (1987) and Bartlett (1999).

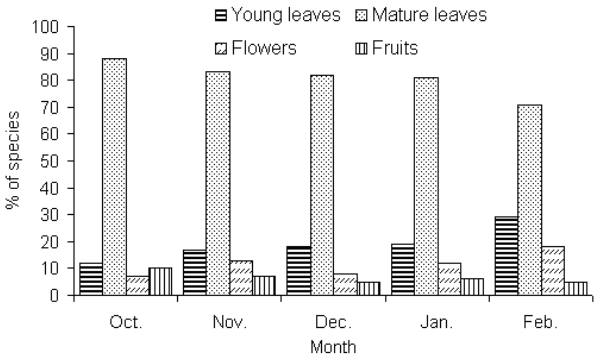

Fig 2. Availability of food resources in different months.

Results

Time spent in a day on different activities was recorded and percentage of the day time on feeding in different months during the observation period is reported here. The average time on feeding was 36.8%, the average maximum feeding time was in December (39.7%) and minimum was in October (33.4%) (Table 1). The difference in average feeding time in the two winter seasons was not significant (t value = 0.790, n = 9). Average time spent eating different food categories that constituted diet is illustrated in Fig 3. A total of 57% of feeding time was spent eating leaves; 42% on young leaves and 15% on mature leaves; 22% on eating flowers; 17% on fruits; 3% on seeds and 1% on other food items, over the winter season. The pattern of time spent feeding on different food items during both the winters was similar.

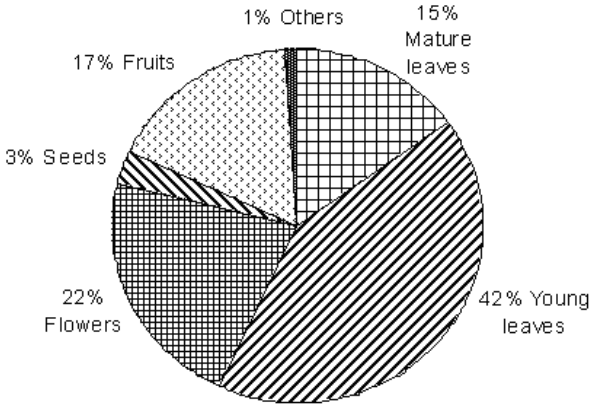

Fig 3. Feeding time on food classes.

Table 1. Average feeding time in different months in two successive winters.

Winter seasons	October	November	December	January	February	Average
	Feeding time (% of total active time of month)					
2001-2002	34.2	37.0	42.2	39.0	37.8	38.0
2002-2003	32.6	34.3	37.3	37.8	36.2	35.6
Mean	33.4	35.6	39.7	38.4	37.0	36.8

Table 2. Percentage of total time spent on feeding major food categories.

Months	Plant parts eaten			
	Leaves	Fruits & Seeds	Flowers & Buds	Others
October	67.5	19.5	11.7	1.3
November	60.1	16.0	20.8	3.0
December	58.5	15.8	25.4	0.3
January	46.9	35.6	17.1	0.5
February	51.5	12.1	35.2	1.2
Mean (± SD)	56.9 (±8.0)	19.8 (±9.2)	22.04 (±8.9)	1.26 (±1.1)

Table 3. Food part eaten by *T. pileatus* and feeding time (%) on each plant in winter months.

Food plant species	Family	Oct (%)	Nov (%)	Dec (%)	Jan (%)	Feb (%)	Mean (%)
	Only young leaves						
Mikania micrantha Kurth.[3]	Asteraceae	15.3	14.2	9.8	11.9	4.9	11.2
Duranta plumeri Jacq. Var. [2]	Verbenaceae	2.2	4.0	4.6	5.2	2.4	3.7
Persea globosa (A. Das) Kosterm[1]	Lauraceae	0.4	4.1	5.3	1.9	--	2.3
Litsea monopetala (Roxb.) Pers[1]	Lauraceae	0.9	0.8	1.2	2.7	4.6	2.0
Bischofia javanica Blume. [1]	Euphorbiaceae	--	1.4	2.3	1.2	1.6	1.3
Alstonia scholaris (Linn.) R.Br. [1]	Apocynaceae	1.2	1.7	2.2	1.4	0.3	1.4
Amoora wallichii King. [1]	Meliaceae	2.1	1.6	2.4	--	--	1.2
Syzygium formosum (Wall.) Masam. [1]	Myrtaceae	--	--	--	0.2	2.6	0.6
Toona ciliata M. Roem[1].	Meliaceae	1.7	1.4	1.7	0.5	0.0	1.1
Syzygium malaccansis L. [1]	Myrtaceae	0.9	1.2	0.1	--	0.7	0.6
Horsfieldia kingii (Hook. f.) Warb.[1]	Myristicaceae	--	--	--	1.4	0.8	0.4
Aesculus assamica Griffith[1]	Hippocastanaceae	1.3	0.4	--	--	--	0.3
Stereospermum chelonoides (Linn.) DC. [1]	Bignoniaceae	--	--	1.1	--	0.3	0.3
Vitis planicaulis Hook.f. [3]	Vitaceae	--	--	0.0	1.1	0.2	0.3
Hibiscus fragrans Roxb. [2]	Malvaceae	--	--	--	0.7	--	0.1
Caesalpinia bonduc (L.) Roxb.[2]	Caesalpiniaceae	--	--	--	0.6	--	0.1
Zanthoxylum rhetsa Roxb. DC[1]	Rutaceae	--	--	--	0.4	--	0.1
Chukrasia tabularis A. Juss. [1]	Meliaceae	--	--	--	--	0.4	0.1
Piper pedicellatum C. DC. [3]	Piperaceae	--	--	--	--	0.5	0.1
Spondias pinnata (L.f.) Kurz. [1]	Anacardiaceae	--	--	--	0.5	--	0.1
Syzygium syzygioides Merr. & Perry[1]	Myrtaceae	--	--	--	--	0.2	0.1
	Young and mature leaves						
Ficus glomerata Roxb.[1]	Moraceae	9.2	19.2	21.1	14.8	21.2	17.1
Albizia lucida Benth. [1]	Mimosaceae	17.3	7.1	6.9	22.4	6.7	12.1
Gmelina arborea Roxb. [1]	Verbenaceae	15.9	6.4	2.9	4.8	8.0	7.6
Albizia procera (Roxb.) Benth. [1]	Mimosaceae	1.7	6.9	7.1	8.5	2.3	5.3
Euodia glabrifolia (Champ.) Balakr. [1]	Rutaceae	1.2	3.3	5.7	3.0	8.1	4.3
Morus laevigata Wall. [1]	Moraceae	--	--	--	--	5.1	1.0
	Young leaves and flower						
Ficus religiosa Linn. [1]	Moraceae	--	--	--	0.9	0.6	0.3
Terminalia bellirica (Gaertn.) [1] Roxb.	Combretaceae	--	--	--	--	0.6	0.1
	Only flowers						
Kydia calycina Roxb. [1]	Malvaceae	15.5	20.7	16.9	0.0	0.0	10.6
Bauhinia purpurea Linn. [1]	Caesalpiniaceae	0.7	0.9	2.3	1.5	0.2	1.1
	Only flower buds						
Elaeocarpus obtusus Blume. [1]	Elaeocarpaceae	--	--	--	--	2.8	0.6
	Flowers and flower buds						
Bombax ceiba Linn. [1]	Bombacaceae	2.7	1.3	1.6	3.3	9.8	3.8
Sterculia villosa Roxb. [1]	Sterculiaceae	--	--	--	1.2	11.8	2.6

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Table 3. Continued.

Food plant species	Family	Oct (%)	Nov (%)	Dec (%)	Jan (%)	Feb (%)	Mean (%)
	Only fruits						
Castanopsis armata Spach [1]	Fagaceae	0.7	0.9	1.8	0.3	0.6	0.9
Artocarpus chaplasha Roxb. [1]	Moraceae	0.6	--	--	--	--	0.1
Artocarpus lakoocha Roxb. [1]	Moraceae	--	0.4	1.2	--	--	0.3
Cinnamomum glanduliferum Meissm. [1]	Lauraceae	--	--	0.3	2.0	0.8	0.6
	Flower and fruits						
Anthocephalus cadamba (Roxb.) Miq[1].	Rubiaceae	2.7	1.4	0.3	1.4	0.0	1.2
Dillenia indica Linn. [1]	Dilleniaceae	3.0	1.7	1.5	4.6	1.2	2.4
	Flower, fruits and flower buds						
Ficus bengalensis Linn. [1]	Moraceae	0.6	--	0.2	1.7	0.9	0.7
	Fruits and seeds						
Cassia nodosa Buch. Ham. [1]	Caesalpiniaceae	0.9	--	--	0.0	--	0.2
	Shoots						
Dendrocalamus hamiltonii Nees & Arn.[4]	Bambusaceae	1.4	--	--	--	--	0.3

1-Tree, 2- Shrub, 3-Climber, 4 - Bomboo

Monthly variations in diet

Time spent feeding on different food items varied considerably across the months (Table 2). The maximum time spent feeding on leaves was in October (67.5%) and the lowest (46.9%) was in January. The maximum time (35.6%) spent eating fruits and seeds was recorded in January and the lowest (12.1%) in February. Time spent eating flowers and flower buds was more (35.2%) in February and was lowest (11.7%) in October. Feeding on other items such as gum, bark, and soil was occasional, ranging from 0.3% in December to 3.0% in November.

Food plant species and dietary diversity

T. pileatus was observed feeding on 43 plant species, which belong to 27 families (Table 3). Of these plant species, 36 were trees, 3 climbers, 3 shrubs and 1 was bamboo. Six food plants belong to Moraceae, 3 each to Caesalpiniaceae, Lauraceae, Meliaceae, Myrtaceae; and 2 each to Malvaceae, Mimosaceae, Rutaceae and Verbenaceae. Eighteen plant families were explored by langurs for their diet. Capped langurs obtained leaves from 33 plant species, fruits from 15 species, flowers from 10 species, and seeds from 6 species. The average number of plant species eaten was maximum in February and least in November.

Dietary pattern was identified on the basis of the length of feeding time spent on different food plant species. Plant species were ranked, each month, between 1 and 10 on the basis of time spent in feeding on them (Table 4). *T. pileatus* spent an average of 20.4% of total feeding time on plant species ranked 1st, 65.0% of feeding time was devoted on 1st to 5th ranked plant species and 84.2% of feeding time on 1st to 10th plants species. Thus, langur derived dietary items mainly from ten plants namely *Ficus glomerata, Albizia lucida, Mikania micrantha, Kydia calycina, Gmelina arborea, Albizia procera, Euodia glabrifolia, Bombax ceiba, Duranta plumeri, Dillenia indica.* Parts of these plants constituted to the diet of langur.

Table 4. Time spent (%) in feeding on plant species ranked between 1 and 10, in different months.

Months	Species with 1st rank	Species with 1-5 rank	Species with 1-10 rank
October	17	73	86
November	21	68	88
December	21	62	83
January	22	63	81
February	21	59	83
Mean (±SD)	20.4 (±1.9)	65.0 (±5.5)	4.2 (±2.8)

Selectivity

The plant species on which animal spent ≥1% of total feeding time was considered to be major food tree species. Eighteen food tree species constituted this category (Table 5). The species on which the feeding time ranged between 5-10% of the total were considered most chosen plant species. The species in this category were *Gmelina arborea* and *Albizia procera*. The plant species on which feeding was more than 10% of the total feeding time were considered most preferred. These plants were *Ficus glomerata, Albizia lucida* and *Kydia calycina.* The flowers of *Kydia calycina* were very frequently eaten from October to December. The selectivity of food plant species was not based on the density of major food trees; *Amoora wallichii* had the highest density but the animal had low feeding on it, whereas *Ficus golmerata, Albizia lucida, Kydia calycina* were lower in density and langurs had more feeding on them. Thus the feeding time on the food tree species was density independent.

Table 5. Density of major food tree species eaten and feeding time (%) on them.

Species	Tree density (Trees ha^{-1})	Feeding time (%)
Amoora wallichii	56	1
Gmelina arborea	50	8
Ficus glomerata	38	17
Albizia procera	28	5
Bombax ceiba	19	4
Albizia lucida	16	12
Dillenia indica	15	2
Sterculia villosa	15	3
Toona ciliata	14	1
Morus laevigata	13	1
Euodia glabrifolia	13	4
Kydia calycina	11	11
Bischofia javanica	11	1
Persea globosa	10	2
Litsea monopetala	10	2
Alstonia scholaris	10	1
Anthocephalus cadamba	8	1
Bauhinia purpurea	1	1

Average tree density (per ha) = 18.7 (n= 18)

Discussion

Time spent by herbivores on various activities including feeding is influenced by various environmental factors, habitat condition and food availability. The availability of food, its distribution in natural habitat and food value of plant species are subject to seasonal variations (Ganguly *et al.* 1964; Majumdar *et al.* 1967; Tejwani 1994). This has profound influence on the activity pattern of the animals (Solanki 2000, 2003). Time on particular plant species and food items to be eaten are decided by the phenological stages and to what extent the nutrient requirement is fulfilled (Freeland & Janzen 1974; Milton 1980). Consumption of leaves, 57% in diet, probably satisfied the nutrient requirement; young leaves (42% in diet) are reported to contain high percentage of crude protein (Krishnamani 1994; Struhsaker 1975) and maintain the internal environment of foregut where digestion of food item occurs (Davies 1984; Waterman *et al.* 1988) in colobines. The abundance of young leaves in the diet of colobine monkeys maintains the high ratio of cell sap to cell wall that results in high digestibility (Oates *et al.* 1980). Availability of young leaves further contributes to whether or not a particular species is chosen for food. Fruits and flowers constituted the major part of the diet, next to leaves. The food plants and food items eaten by *T. pileatus* were similar in the two winters. This indicates consistency in selection for food. However, as ambient temperature decreased during the study period, the choice gradually shifted from leaves to flowers (Table 2). Thus temperature, apart from phenology, appears to play a role in selection of food item and diet composition. Primates, like other animals, require protein for growth and replacement of tissue, carbohydrate and fat for energy, and various trace elements and vitamins and other essential nutrients. Protein comes from prey animals like insect and smaller vertebrates and from leaves particularly young ones. Leaves and prey are alternatives in a primate's diet to some extent (Jolly 1985). *Trachypithecus pileatus* was not observed eating insects for protein requirement unlike in some species of *Trachypithecus, Semnopithecus entellus* and *Macaca radiata* which occasionally feed on insects (Krishnamani 1994; Poirier 1970; Roonwal & Mohnot 1977).

Monsoons activate from April-May to September-October in the study area, therefore, tender leaves remain available on climbers like *Mikania micrantha, Piper pedicellatum* and *Vitis planicaulis*. All three climbers and three shrub species accounted for 12% and 4%, respectively, in the winter diet. As the dry spell begins, structural changes in leaves lead to maturity. This maturation of leaves leads to a gradual decline in feeding time on them (Table 2). Simultaneously, feeding increases on young leaves. Studies in Madhupur forest in Bangladesh showed that the capped langurs' staple food was mature leaves in winter and time spent eating mature leaves was 65.1% in November (Stanford 1991a, 1992). In our study, mature leaves accounted for 11.8% of the diet in the same month. Thus, it may be stated that phenological stages of plants influence the feeding time and selection of food items. Winter spell of rains in December and January and rise in temperature from February onwards initiates sprouting in plants resulting into availability of young leaves, and thus a shift in preference.

The most important sources of tender leaves or tender part of leaves in our study were *Ficus glomerata, Mikania micrantha*, *Gmelina arborea*, *Duranta plumeri,* important source of the flowers was *Kydia calycina* that accounted on average 18% of the diet from October to December (Table 3). Stanford (1991 b) in Bangladesh reported that *Malvesia* spp. was the most important source of flowers and mature leaves, and 14% of diet of *T. pileatus* was constituted by young leaves during winter months. However, Mukherjee (1978) observed that the capped langur selected leaves of *Lagerstroemia parviflora*, fruits of *Bridelia retusa*, and flowers of *Salmalia malabarica* in their diet in winter in Tripura. It appears from this comparison that habitat and vegetation type could modify food plant selection and diet of *T. pileatus*.

The capped langur exhibits a bi-modular pattern of breeding : the first phase is longer and extends from September to January, while the second phase is shorter and falls in April and May (Solanki *et al*. 2007). Demand for energy increases during pre-mating and mating periods. Leaves, fruits and flowers become the main source of energy supplements. These require less energy investment during digestion but the net energy gain is high (Arnold 1981; Black & Kenney 1984; Becker & Loharmann 1992). Mating activities increase during October and November as compared to other months of breeding season (Solanki *et al*. 2007). This increased mating is accomplished at the cost of feeding time. Mating activities slow down gradually when the animal increases the feeding time and selects energy rich food items such as fruits & seeds and flowers to compensate for the energy losses. The most important source of energy at that time are flowers of *Kydia calycina* that accounted on average 18% of the diet from October to December. We recorded some anecdotal observations during this study and found that the females with infants specifically eat these food items more. Pregnant and lactating females require more protein than carbohydrates (Herrera & Heymann 2004; Kumar & Solanki 2004) and have been observed occasionally feeding on aquatic plants (Kumar & Solanki 2004).

T. pileatus frequently preferred tree species during the winter season inspite of sufficient availability of climbers. Average feeding time on each species indicates that *Ficus glomerata* attracted maximum feeding time (17.10%) followed by *Albizia lucida* (12.09%), *Mikania micrantha* (11.22%), *Kydia calycina* (10.61%), *Gmelina arborea* (8%), and *Albizia procera* (5%). Other plant species contributed < 5% to total winter diet. Total number of trees and density of tree species did not influence the preference of food tree. Trees of Moraceae family dominated the diet of langur during winter months and accounted for 19.5% of winter diet. Fashing (2001) and Kool (1989) also reported that trees of the Moraceae family dominate the diet of *Colobus guereza* at Kakamega Forest, western Kenya and *Trachypithecus auratus* at Pangandaran, Indonesia. Trees of the family Moraceae are large in size, have large canopy and different plant species keep providing young leaves consistently during winter months. Terminal canopy is the preferred feeding site of *T. pileatus* (Solanki *et al*. 2008). Thus folivorous primates may save energy through steady foraging for long periods of time with little movement from branch to branch or tree to tree (Clutton-Brock & Harvey 1976). This is especially advantageous to pregnant animals (Chapman 1990; Nakagawa 1990). Large trees with dense canopy also provide protection from natural predators. Stevenson *et al*. (1994) and Yiming *et al*. (2002) also indicated that size of the tree is an important parameter for its selection as food tree for arboreal primates. It has

been reported by Solanki *et al.* (2008) that capped langurs spend 40% of their feeding time on terminal canopy and an average feeding height on trees vary between 30-35 m. They also mentioned that large food trees are generally preferred over smaller ones of the same species or different species.

Dietary composition varied each month considerably during the study period. Solanki *et al.* (2008) also reported this trend in dietary composition on the basis of twelve months study on langurs. In the months of lowest food abundance, capped langur exploited the greatest number of food species. This pattern is broadly consistent with optimal foraging theory (Pyke *et al*. 1977; Schoener 1971). As the rank position of preferred foods decreases, the time to procure them increases, animal might be expected then to turn towards the plants of lower rank value. Oates (1977) stated that no consistent pattern has yet emerged among primates in general. All species do not increase the breadth of their diet when faced with reduced resource availability. Nevertheless, it appears likely because primates need to balance their dietary requirements and restrictions, such as calories, digestibility and secondary (or toxic) compounds (Richard 1985). Furthermore, primates may alter their feeding strategy in relation to the availability of specific resources, or even individual trees (Chapman 1988 b).

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