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SHORT COMMUNICATIONS

Feeding ecology of capped langur (*Trachypithecus pileatus*) in Sri Surya Pahar, a disturbed habitat in Goalpara District, Assam, India

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Abstract
A group of capped langurs, *Trachypithecus pileatus* comprising eight individuals was observed for feeding behavior in Sri Surya Pahar, an archaeological site of religious importance and degraded habitat, located about 12 km southeast of Goalpara town in Assam. The feeding ecology of the species was studied by recording the time spent feeding on different food plants and food categories during different seasons of the year. Scan sampling method was followed from dawn to dusk to record data on various aspects of feeding. Capped langurs spent 37.87% of their total active time in feeding during winter season, 34.12% in pre-monsoon, 26.60% in retreating monsoon, and 26.08% in monsoon season. Altogether 41 species of plants belonging to 24 families were utilized for feeding throughout the year. Capped langurs spent maximum time feeding on leaves. The time spent on feeding new leaves was highest during pre-monsoon season (63.70%) and lowest in winter (7.82%). While the time spent on feeding mature leaves was highest in winter (67.48%) and lowest in pre-monsoon season (2.31%). The time spent feeding flowers (20.78%) was maximum in winter and that on unripe fruits (20.79%) and petioles (9.24%) was maximum in pre-monsoon season. Flower buds, leaf buds, latex and insects were placed in 'others' category and were consumed in low quantity. From this study, a significant change was observed in the diet composition of Capped langurs during different seasons. Habitat degradation due to encroachment is the major threat to this endangered species in Sri Surya Pahar and its neighbouring areas. The study focused on the feeding ecology of capped langur in a degraded habitat. Therefore, the information generated from this study could be useful for evaluation and improving the quality of the habitat and formulating conservation and management action plan for capped langur.

Keywords Capped langur · Food categories · Food plants · Goalpara · Habitat degradation · Sri Surya Pahar

Introduction

Diet composition and the distribution of resources have strong influence on activity budgets of primates. Decemson et al. (2018) reported that flexibility in the allocation of time to various activities enables animals to adapt to a set of habitat conditions, including variation in food availability. Capped langurs are the least studied folivorous primates in India and information on their food and feeding behaviour is scanty. The capped langur, *Trachypithecus pileatus* (Blyth, 1843) is an endangered (EN) species as per the IUCN (International Union for Conservation of Nature) Red List of Threatened Species (Das et al. 2020). The Indian Wildlife (Protection) Act, 1972 has placed the species in Schedule-1 category. They are endemic to Northeast India (Srivastava 1999) and their global distribution is restricted to Bangladesh, northwestern Myanmar, Bhutan, and southern China (Roonwal and Mohnot 1977; Zhang et al. 1981; Khan and Ahsan 1986; Ahsan 1994; Srivastava 1999).

Very few studies on their feeding behavior were documented such as Stanford (1991) in Bangladesh, Choudhury (1989), Gupta (1998) and Solanki et al. (2008a, b) in northeast India, but information on their feeding ecology is degraded habitat is scanty. The degraded forest areas are structurally distinct in terms of tree species composition and reduced food availability (Dunham

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2017). The present study was planned to understand the feeding ecology of capped langur in degraded habitat where food quality and quantity is inadequate. The aim of the study was to determine the total feeding time and time spent feeding food plants and food categories in different seasons. The information generated through this study could be helpful in habitat management and conservation of this endangered species of primate.

Materials and methods

Study area

The Sri Surya Pahar is situated at 26°05′N and 90°42′E with an area of 3.42 sq.km. (342 ha). It is located on the south bank of the Brahmaputra River in the district of Goalpara, Assam (Fig. 1). The vegetation of the Sri Surya Pahar is mixed deciduous type. It is the abode of three species of primates: the Assamese macaque (*Macaca assamensis*), rhesus macaque (*Macaca mulatta)* and capped langur (*Trachypithecus pileatus*). According to personal communication from the local residents there are past records of the hoolock gibbon (*Hoolock hoolock*) and the slow loris (*Nycticebus bengalensis*) from the area. The district receives an average annual rainfall of 2739 mm. The maximum average annual temperature is 28.4 °C and the minimum is 17.8 °C. The warmest month of the year is August and January is the coldest month of the year. Average relative humidity is 81%. The average elevation is 35 m (114 ft.) above sea level.

The data collection period was of 12 months and it was divided into four seasons as per Barthakur (1986). The seasons were winter (December–February), pre-monsoon (March–May), monsoon (June–September) and retreating monsoon (October–November). Data collection period varied from season to season based on available day light time and visibility.

Data collection

Study group

A one-male multi-female group comprising eight individuals was selected for recording data on food and feeding behavior for 12 months covering all seasons of the year. The group included one adult male (AM), three adult females (AF), one sub-adult male (SAM), one sub-adult female (SAF), one juvenile male (JuM) and one

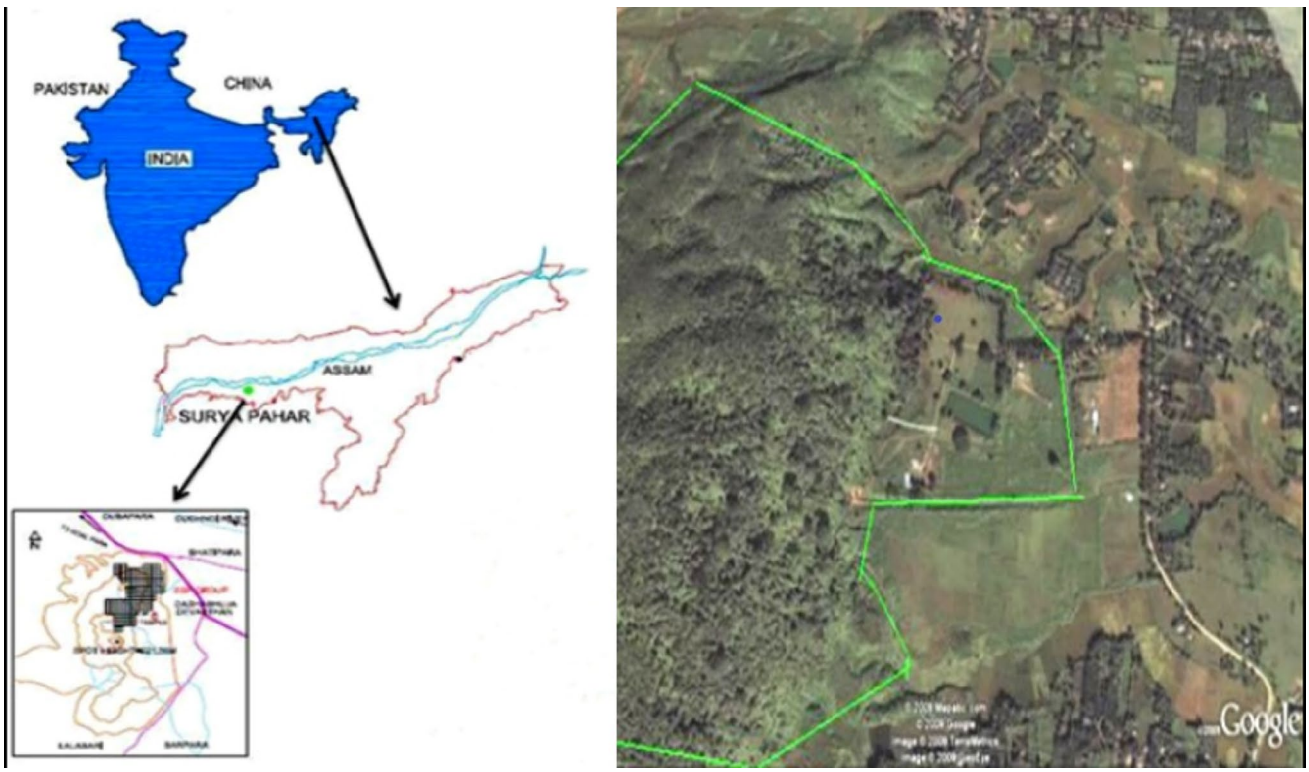

Fig. 1 Location of the study area

Table 1 Composition of study troop

Adult male (AM)	Adult female (AF)	Sub-adult male (SAM)	Sub-adult female (SAF)	Juvenile male (JuM)	Infant female (InF)	Total
1	3	1	1	1	1	8

infant female (InF) (Table 1). Initially, an additional 3 month's time was spent to get the group habituated with the presence of the observer. The capped langur under study belonged to the subspecies *Trachypithecus pileatus pileatus* which is commonly known as blond-bellied langur.

The Scan sampling method (Altmann 1974) was adopted to record the data on instantaneous activities of all the group members viz. feeding, resting, locomotion, grooming, monitoring and social interactions every 10 min over a 30-min session. A dawn-to-dusk profile of the activity status of each animal in the study group was recorded during the study period.

The study group was followed as soon as they left the overnight resting tree just after sunrise between 05:00 and 05:30 h until the individuals ceased their activity after sun set between 17:30 and 18:00 h. A total of 591.6 h covering 48 days (12 days/season) was spent on data collection. The seasonal variation in feeding ecology was calculated on the basis of the feeding scores in term of time. The time the group spent eating different plant species and plant parts was recorded. The plant parts eaten by the group were categorised as new leaves (NL), mature leaves (ML), leaf bud (LB), flowers (Fl), ripened fruits (RF), unripe fruits (URF), petioles (PET), bark (BA), stem (ST) and others (seed, vegetative shoot**,** latex, insects and their larvae).

Results

The capped langur started feeding actively in early morning immediately after sunrise and in the evening just before settling down to sleep. Intensity of feeding bouts found declines as day progressed because they had to move in search of suitable food and feeding site.

Food plant species eaten

A total of 41 species of plants belonging to 24 families were eaten by capped langurs across the seasons during the study. Twenty-four species of tree, eleven species of lianas, three species of herb and three species of shrub were used for feeding by capped langurs in the study area (Table 2).

Seasonal variation in total feeding time

Total feeding time gradually declined across the seasons; winter to retreating monsoon. Maximum feeding time was devoted in winter (37.87%) and minimum was in retreating monsoon (26.08%) (Fig. 2).

Seasonal variation in feeding on different food items

The capped langur spent the highest amount of time feeding on leaves. Time spent consuming new leaves was highest in the pre-monsoon (63.70% of total feeding time) and was the lowest in winter (7.82%). However, consumption of mature leaves was highest in winter (67.48%) and lowest in pre-monsoon (2.31%). Details of time spent feeding different food items in different seasons are given in Table 3.

Capped langurs spent 20.78% of feeding time on flowers in winter; it was negligible in other seasons. Time spent on consuming unripe fruits was 20.79% of feeding time during pre-monsoon season; it was negligible in other seasons. The groups spent an insignificant time feeding on stem, petioles, ripe fruits, and bark across the seasons (Table 3). Flower buds, leaf buds, latex and insects were placed in 'other' category and insignificant time given to this category.

Discussion

In degraded habitat we found capped langurs to utilize 41 plant species, but the plant species and parts consumed varied over time in this study. Time devoted on feeding was highest in winter (37.87%). Winters being dry season, food resources become scarce and mature leaves are in abundance in comparison to monsoon and retreating monsoon. In degraded habitat, number of food plants selected and spectrum of diet is less than that of undisturbed and protected habitat. Habitat quality, seasonal availability of food resources influences feeding behaviour of capped langur for their selection for food plants and diet (Marsh 1986; Stanford 1991; Solanki et al. 2008a; Decemson et al. 2018).

Table 2 Plant species and their parts eaten by capped langur in different seasons

Botanical name	Family	Season	Parts consumed	Habit
Eupatorium odoratum Linn	Asteraceae	W	ML, FL	Herb
Albizia procera (Roxb.) Benth	Mimosaceae	W	ML	Tree
Linnea grandis A. Rish	Anacardiaceae	W	Ml, NL	Tree
Ficus glomerata Roxb	Moraceae	W	PET,URF, NL	Tree
Ficus hispida Linn	Moraceae	W	ML, NL, URF	Tree
Adhatoda vasica Ness	Acanthaceae	W	FL	Herb
Mikania micrantha Kunth	Asteraceae	W	ML, NL	Liana
Mallotus philippensis (Lam.) Muell. Arg	Euphorbiaceae	W	ML	Shrub
Litsea monopetala (Roxb.) Perx	Lauraceae	W	NL	Shrub
Spondias pinnata Kurz	Anacardiaceae	W	RF	Tree
Hodgsonia macrocarpa (Bl.) Cogn	Cucurbitaceae	W	ML	Liana
Garuga pinnata Roxb	Anacardiaceae	W	FL, NL, ML	Tree
Mimosa invisa Martius ex Colla	Mimosaceae	W	ML, NL	Herb
Paederia foetida Linn	Rubiaceae	W	NL,ML	Liana
Aralia foliolosa Seem. ex C.B. Clarke	Araliaceae	W	ML,NL	Liana
Acida sps.	Euphorbiaceae	PM	URF	Tree
Artocarpus chama Roxb	Moraceae	PM	NL, ML	Tree
Samanea saman (Jacq.) Merr	Mimosaceae	PM	NL,ML	Tree
Rhamnus nepalensis (Wall.) Lawson	Rhamnaceae	PM	NL,ML	Tree
Tetrameles nudiflora R.Br	Datiscaceae	PM	NL	Tree
Plumeria alba Linn	Apocynaceae	PM	NL	Tree
Aegle marmelos Correa	Rutaceae	PM	NL, URF, FL	Tree
Ficus elastica Linn	Moraceae	PM	NL	Tree
Syzigium cumini (L.) Skeels	Myrtaceae	PM	URF	Shrub
Hoya parasitica (Roxb.) Wall. ex Traill	Asclepidaceae	PM	NL,FL	Liana
Argyreia nervosa (Burm.f.) Bojer	Convolvulaceae	PM	NL	Liana
Ipomoea carnea (Mart. ex Choisy) D.F. Austin	Convolvulaceae	PM	NL	Liana
Peltophorum ferrugineum (Decne.) Benth	Mimosaceae	M	URF	Tree
Cedrela toona Roxb. ex Rottler & Willd	Meliaceae	M	NL, ST, BA	Tree
Ficus religiosa Linn	Moraceae	M	ML,NL,LB	Tree
Ficus bengalensis Linn	Moraceae	M	NL,LB	Tree
Cissampelos pareira Linn	Menispermaceae	M	ML	Liana
Cassia siamea Lam	Caesalpinaceae	M	NL,ML	Tree
Natsiatum herpeticum Buch.-Ham. ex Arn	Icacinaceae	M	ML	Liana
Tinospora cordifolia (Willd.) Hook.f. & Thomson	Menispermiaceae	M	NL, ML	Liana
Tectona grandis L.f	Verbenaceae	M	NL	Tree
Cassia fistula Linn	Caesalpinaceae	RM	NL, FL	Tree
Anthocephalus cadamba (Roxb.)Miq	Rubiaceae	RM	PET, RF	Tree
Bombax ceiba Linn	Bombacaceae	RM	NL	Tree
Gmelina arborea Roxb	Verbenaceae	RM	NL	Tree
Dioscoria sps.	Dioscoreaceae	RM	NL,ML	Liana

NL new leaves; *ML* mature leaves; *LB* leaf bud; *FL* flowers; *RF* ripe fruits; *URP* unripe fruits; *PET* petioles; *BA* bark, *ST* stem and others

Allocation of feeding time depends on quality of food and temperature conditions of the area (Ding and Zhao 2004; Hanya 2004); these conditions also influence energy intake, and other activities such as resting and social activities in primates (Oates 1987; Dunbar 1992; Huang et al. 2003).

Diet of capped langurs in degraded habitat included almost all parts of plants, predominated by leaves, an average of 78.25% of feeding time was spent consuming leaves, which includes 36.49% feeding time on new leaves and 41.76% feeding time on mature leaves. Time

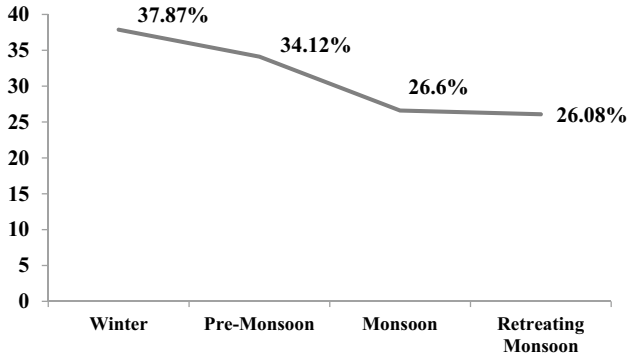

Fig. 2 Time (%) spent in feeding in different seasons

spent on consuming new leaves was highest in the pre-monsoon (63.70% of time on feeding) and was lowest in winter (7.82%). Pattern of time in foraging mature leaves was reverse of time spent on consuming young leaves. However, consumption of mature leaves was highest in winter (67.48%) and lowest in pre-monsoon (2.31%). Colobine monkeys harbour cellulose-fermenting microfauna in their stomachs and have specialized digestive systems which enable them to eat more leaves and feed selectively on seasonal plants parts (Hladik 1977; Marsh 1981; Oates 1987; Davies 1991; Stanford 1991; Newton 1992). Mature leaves are generally rich in fiber compared to new leaves, which are rich in protein, more nutritious, and have lower processing costs (Milton 1980; Oates et al. 1980; McKey et al. 1981; Estrada 1984; Waterman and Kool 1994). Higher consumption of new leaves than mature leaves in the pre-monsoon season by the study group suggests their requirement of essential nutrients and protein. Similar results were also reported by Struhsaker (1975), Davies (1984) and Kumar and Solanki (2004). On the other hand, mature leaves were used as a preferred food item during the winter season (67.48% of feeding time) mainly because new leaves were available only for a short period mostly in pre-monsoon and monsoon seasons. The other preferred food item during winter was flowers (20.78%).

Out of the 41 plant species utilized by the group, 36 species contributed leaves as food items while 10 species provided multiple food items. The geographical area and climatic conditions in a habitat affects the vegetation structure and composition, which in turn affect the diet selection in colobines (Kirkpatrick 2007; Matsuda et al. 2009; Kirkpatrick and Grueter 2010; Tsuji et al. 2013; Akbar et al. 2019). Larger habitat supports a greater variety of plants and phenological stages. A study by Solanki et al. (2008a, b) on capped langurs found that they ate more number of species (52) than the present study (41 species) but the contribution of leaves (68% of feeding time) to the diet was less in comparison to present study. It might be due to more number of species available in the area since the study was conducted in a protected area (i.e. Pakhui Wildlife Sanctuary, Arunachal Pradesh, India). Food availability also influenced the diet composition in winter season. Proportion of mature leaves eaten reported in this study are unlike the diet composition in winter reported by Solanki et al. (2008b). Despite temporal variation in food supplies, the study group had similar dietary profiles in terms of plant parts consumed with a few notable differences. The group inhabiting a disturbed habitat and with access to fewer food plant species, fed very little on fruit, flowers, seeds and petioles. Thus habitat restoration should undertake with the planting of food plants with multiple food resources which langurs could utilize. Such forestry activity will improve the quality of habitat and facilitate the conservation of this endangered species in such habitat along with faunal groups in Goalpara district and also in other parts of Assam (Fig. 3).

Table 3 Proportion of feeding time spent feeding on different food items within each season

Food categories	Winter (%)	Pre-monsoon (%)	Monsoon (%)	Ret-monsoon (%)
New leaves	7.82	63.70	37.70	36.75
Mature leaves	67.48	2.31	46.65	50.60
Petiole	2.20	9.24	4.15	2.41
Leaf bud	0.00	0.00	1.60	1.81
Flower	20.78	1.16	0.00	0.00
Ripe fruit	1.71	0.00	0.00	0.00
Unripe fruit	0.00	20.79	0.00	0.00
Bark	0.00	2.15	6.39	3.01
Stem	0.00	0.17	3.51	5.42
Other	0.00	0.50	0.00	0.00
Total	100	100	100	100

Fig. 3 Feeding activities of capped langurs in the study habitat. **a** An adult female feeding on new leaves of *Argeria nervosa* **b** Sub-adult female feeding on unripe fruit of *Ficus glomerata.* **c** Juvenile male feeding on petioles of *Ficus sps.* **d** A sub-adult male feeding on bark of *Linnea grandis*

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