Feeding Ecology of Assamese Macaque (*Macaca assamensis)* in Nagarjun Forest of Shivapuri Nagarjun National Park, Nepal

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Abstract

Macaques have been described as primarily frugivorous but Assamese macaques are highly folivorous and are omnivorous according to some studies. Systemic studies in feeding ecology of Assamese macaque is rare in Nepal; so to explore the feeding ecology of the macaque this study was carried out in the Nagarjun Forest of Shivapuri Nagarjun National Park (SNNP) during rainy and autumn seasons of 2012. Two troops of the macaques from different two sites were selected for the study and scan sampling was adopted to collect the data.

There was significant difference in diet composition between two troops of macaque studied; one feeding on waste food from Army canteen area and the next is totally dependent on natural food. Unlike other studies macaques were highly frugivorous during the study period, fruit accounted for 80.48% of the total plant parts consumed and majority of fruits came from four plant species: *Castanopsis tribuloides*, *Syzygium cumini, Machilus duthiei* and *Choerospondias axillaris*. Macaques were observed to forage on 37 plant species which include 22 families, 28 species of tree, four species of vine, three species of shrubs and two species of herbs. *Castanopsis tribuloides, Syzygium cumini* and *Machilus duthiei* accounted for 29.01%, 15.26% and 15.26% respectively of the total plant diet. IVI for the entire feeding tree were 206.4 and 203.4 in two study sites. Most of food species in both sites are patchily distributed in space.

***Key words*:** Diet, Macaques, Scan sampling, SNNP, Vegetation

Introduction

Although most primates are largely frugivorous, diets are diverse and can include ripe or unripe fruit pulps and seeds as well as leaves, exudates, and other plant parts or animals in various proportions (Rosenberger 1992). A group of primate macaque species have been described as primarily frugivorous (Yeager 1996, O'Brien and Kinnaird 1997, Riley 2007). However, evidence is steadily accumulating that leaves contribute a large proportion of diet in some species (Zhao 1996, Hanya 2004, Zhou et al. 2011). Even within a species and population, considerable dietary variation in terms of plant species and parts eaten may occur (Hanya et al. 2003, Harris and Chapman 2007). Much of these differences can largely be explained as differences in the temporal availability and spatial distribution of fruit resources (Hanya et al. 2003, Hanya 2004).

Assamese macaques spent most of their time on feeding activity (Chalise 2003, Schulke et al. 2011, Sarkar et al. 2012) and they are omnivorous (Boonratana et al. 2008) feeding on leaves, fruits, flowers, seeds, bark, shoot and caterpillar (Chalise 2003, Chalise et al. 2005) and other animal diet like mammals, birds, reptiles, amphibians, spiders and mollusks (Schulke et al. 2011). According to Chalise (2003) and Zhou et al. (2011) they are highly folivorous. Primates are considered to be successful crop raiders because they can cross fences with ease (Newmark et al. 1994, Hill 2002). Assamese macaque also raid crops in hills of Nepal mainly for maize, rice, wheat, millets, potato, fruits etc (Chalise 1999a, 1999, 2003, 2010).

Besides some studies on the feeding ecology of Assamese macaques in Nepal (Chalise 1999, 2003, Chalise et al. 2013); systematic study on the feeding ecology of this species is rare, which is important to understand species ecological adaptation to the environment (Chalise 2000) and it is one of the most important requirements to design the conservation strategy for the species (Chalise 1999, Gupta 2005).

Materials and Methods

Study Area

Shivapuri Nagarjun National Park is situated in the north of Kathmandu valley. The park encompasses two separate forest patches viz: Shivapuri and Nagarjun. Geographically, Nagarjun is located between 27° 43' to 27° 46' north latitude and 85° 13' to 85° 18' east longitude and occupies an area of 16 km^2 (SNNP 2011). The area extends from around 1350 m a.s.l. to 2100 m a.s.l..The study area largely consists of quartzite rock and, secondarily, of limestone, siliceous limestone and calcisilicate rocks (Hagen 1959).

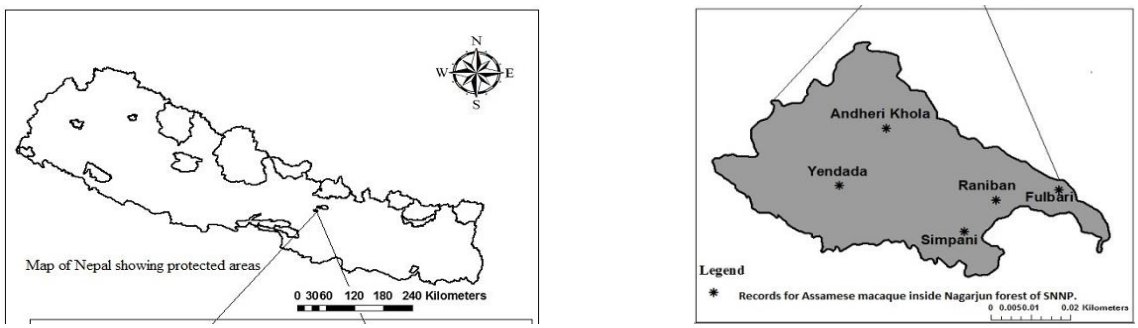

Figure 1. Map of Nagarjun forest of Shivapuri Nagarjun National Park with distribution of Assamese macaque

Nagarjun forest area is a typical Mahabharat hill and bears mostly sub-tropical type of climate and partly temperate climate (Chaudhary 1998). Forests in Nagarjun can be categorized into four types: *Schima wallichii* forest, pine forest, mixed broadleaved forest (*Phoebe lanceolata, Machilus duthiei, Michelia kisopa* as major species) and dry oak forest. There are few small patches of grassy meadow (Kanai and Shakya 1970). The climatic data of the Nagarjun area is not available. So, according to the nearest meteorological station at Panipokari, Kathmandu; average monthly relative humidity (at morning) of the area ranges from 80.73% (April) to 87.42% (August) and average monthly relative humidity (at evening) ranges from 78.73% (April) to 87.73% (September). Similarly, the mean monthly minimum temperatures ranges from 3.9°C (January) to 20.35°C (July) and the mean monthly maximum temperatures ranges from 18.63°C (January) to 29.56°C (Jun).

The fauna present inside Nagarjun forest includes many species of birds, sixteen species of herpetofauna, two primate species Assamese macaque *(Macaca assamensis)* and Rhesus macaque *(Macaca mulata)* many species of bats, squirrels, Chinese Pangolin (*Manis pentadactyla*), Barking Deer (*Muntiacus muntjak*) etc (Wada 2005, Chalise et al. 2013).

Methods

After preliminary survey from 15th to 31st May 2012, among the three troops recorded in Nagarjun forest two troops recorded from Fulbari and Simpani were selected for study of feeding ecology and coded Troop 'A' and 'B' respectively.

Scan Sampling

Scan sampling (Altman 1974) was deployed for data collection and practiced in sloppy areas as by Chalise (2003). Two minutes scan followed by eight minutes of inactivity until the next scan begins was the method applied. In total scan sampling was carried out for 180 hours and 12 minute. General

behaviors like feeding (foraging, feeding and resting chewing food), resting, moving and social/sexual behavior like grooming, playing, aggression and sexual behavior (Caselli and Setz 2011) in which more than half of the troop engaged at the time of scan was recorded in protocol paper. Plant parts and other food items eaten by macaques were observed and noted. Data were collected during rainy and autumn seasons.

Vegetation Sampling

Botanical quadrates of 10 m x10 m was plotted inside the main study area using random systematic sampling method and diameter at breast height (DBH) of trees ≥ 10 cm was measured. In each site, 22 quadrates were plotted. Herbarium was prepared for identification of unidentified plant in the field. Identification was done at National Herbarium Center, Godawari, Lalitpur.

Results

Feeding ecology

Assamese macaques in the study area spent 37.86% of time in feeding and foraging activity, 30.06% in resting, 21.88% in moving and 10.18% of time in social activity.

Among two troops of macaques Troop 'A' feed on waste food from Army Canteen area. The waste food accounted for 36% of their total diet whereas plant items accounted for 57% and crop raiding events were not recorded during this study period for Troop 'A'. Whereas, Troop 'B' is dependent on natural food only; plant parts accounted for 91% of their total diet and they utilized two species of crop i.e. maize (*Zea mays*) and peach (*Prunus persica*) which accounts for 6% during this study. Insect and Honey licking accounted 7% and 3% for 'A' and 'B' Troop respectively. Stone licking by an adult female of troop 'A' was recorded. There was significant difference in diet composition between the two study troops of macaque (χ^2= 98.60, df= 3, p< 0.01).

Feeding records for plant items of two troops was pooled for analysis of prefered plant part by the macaque in study area. Assamese macaque were highly frugivorous during the study period, fruit (including nuts and seeds) accounted for 80.48% of the total plant part consumed and majority of fruits in the diet came from four plant species: *Castanopsis tribuloides*, *Syzygium cumini*, *Machilus duthiei* and *Choerospondias axillaris*. The consumption of young leaves, mature leaves and other items (tuber, Shoot, flower and bud) was low comparing to consumption of fruit and accounted for 8.02%, 5.58% and 5.92% respectively.

Macaques were observed to forage on 37 plant species which include 22 families (excluding families of unidentified 6 species), 28 species of tree, four species of vine, three species of shrubs and two species of herbs (Table 1 and 2) during scan sampling and interval between the scan. Plant feeding records during scan sampling of both troops i.e. 'A' and 'B' of both season was compiled and were found that tree accounted for 69.56% of feeding, shrubs for 8.69%, and vine for 13.04 % and herbs for 8.69 % (Table 1).

Though the macaque forage on large number of plant species, only eight Species such as *Castanopsis tribuloides*, *Syzygium cumini*, *Machilus duthiei*, *Betula alnoides*, *Choerospondias axillaris*, *Maclura conchinchinensis*, *Schima wallichii* and *Trichosanthes wallichiana* accounted for >3% each of all feeding records and contributed for 80.50 % of total plant diet during the study (Table 1). Out of these eight species, *Castanopsis tribuloides*, *Syzygium cumini* and *Machilus duthiei* accounted for 29.01%, 15.26% and 15.26% respectively of the total plant diet.

Vegetation related to macaques' feeding

52% of total tree species recorded were food trees in Fulbari where as only 45% of total recorded tree species were food trees in Simpani. IVI for the entire feeding tree were 206.4 and 203.4 in Fulbari and Simpani respectively. Among the recorded trees highest IVI was for *Schima wallichii* followed by *Machilus duthiei* and *Castanopsis tribuloides* at Fulbari (60.3, 47.4 and 25.8 respectively), whereas at

Simpani highest IVI was for *Castanopsis tribuloides* followed by *Schima wallichii* and *Dodecadenia grandiflora* (50.6, 34.4 and 23.5 respectively); all the mentioned species are food trees of macaque.

Most of food tree species in both sites are patchily or contagiously distributed in space. About 81% of food trees are patchily distributed and 19% are randomly distributed in Fulbari and in Simpani 78% of food tree have patchy distribution and 22% have random distribution. *Schima wallichii* is randomly distributed in both sites.

Table 1. Plant species consumed by Assamese macaque recorded during Scan Sampling at Nagarjun Forest of SNNP

Family	**Species**	**Local name**	**Life form**	**Parts eaten***	**PF****
Anacardiaceae	*Choerospondias axillaris*	Lapsi	Tree	Fr	5.34
Betulaceae	*Betula alnoides*	Saur/ lek Painyou	Tree	YL	6.10
Caprifoliaceae	*Viburnum mullaha*	Mahelo	Vine	Fr	0.38
Cucurbitaceae	*Trichosanthes wallichiana*	Indreni	Vine	L, YL, tendrils	3.05
Ebenaceae	*Diospyros virginiana*	Haluwabed	Tree	Fr	0.38
Fagaceae	*Castanopsis tribuloides*	Musure Kattus	Tree	Fr, Fl	29.007
Lauraceae	*Dodecadenia grandiflora*	Panhele	Tree	Fr	1.14
	Machilus duthiei	Jhangrikath	Tree	Fr	15.26
Loranthaceae	*Scurrula parasitica*	Ainjeru	Shrub	Fr	2.67
Moraceae	*Ficus lacor*	Kapro	Tree	YL, B	1.14
	Ficus religiosa	Peepal	Tree	Fr	0.38
	Ficus sarmentosa	Bedulo	Tree	YL, Fr	1.14
	Ficus semicordata	Khaniya	Tree	Fr	1.52
	Maclura conchinchinensis	Damaru	Vine	Fr, YL, shoot without bark	3.05
Myrtaceae	*Syzygium cumini*	Jamun	Tree	Fr	15.26
Rhamnaceae	*Zizyphus incurve*	Hade bayar	Tree	S	2.67
Theaceae	*Schima wallichii*	Chilaune	Tree	L, YL, Fr	3.43
Tiliaceae	*Grewia asiatica*		Tree	Fr	1.52
Ulmaceae	*Celtis australia*	Khari	Tree	Fr	1.908
Verbenaceae	*Lantana camara*	Masino Kanda	Shrub	Fr, Fl	1.52
Zingiberaceae	*Cautleya spicata*	Pani saro	Herb	Tuber and Stem	0.38
	unidentified 1		Tree	YL	1.52
	unidentified 2		Herb	L,YL	0.76

*YL: Young leaf, B: Bud, Fr: Fruit, Fl: Flower, S: Seed, L: Leaf ** PF: Percentage of total feeding records

Table 2. Food plants of Assamese macaque recorded during interval between scan sampling in Nagarjun Forest of SNNP

Family	Species	Local name	Life form	Parts eaten
Anacardiaceae	*Rhus spp.*		Tree	Shoot without bark
Bombacaceae	*Bombax ceiba*	Simal	Tree	Fruit, flower, bud
Lauraceae	*Lindera nacusua*	Panhelo Khapate	Tree	Fruit
Leguminosae	*Bauhinia purpurea*	Tanki	Tree	Shoot without bark
	Entada phaseoloides	Pangra	Vine	Seed (immature)
Myricaceae	*Myrica esculenta*	Kafal	Tree	Fruit
Rhamnaceae	*Zizyphus mauritiana*	Bayar	Tree	Fruit
Rosaceae	*Prunus cerasoides*	Payou	Tree	Young leaf and flower
Saurauiaceae	*Saurauia napaulensis*	Gogan	Tree	Fruit and Shoot
Verbenaceae	*Caryopteris spp.*	Khorsane Ghas	Shrub	Flower
	Unidentified 3		Tree	Fruit
	Unidentified 4		Tree	Fruit
	Unidentified 5		Tree	Fruit
	Unidentified 6		Tree	Fruit

Discussion

Some studies have been undertaken on the diet of Assamese macaques in the highlands of Nepal, China, Bhutan and India, and have concluded that they are primarily folivorous (Ahsan 1994, Srivastava 1999, Chalise 2003, Zhou et al. 2011, Chalise 2013). But in this study the diet of Assamese macaque in Nagarjun forest of SNNP was highly frugivorous; fruits accounted for 80.48% of the total plant feeding records, where leaf and young leaves only constituted 5.58% and 8.02% respectively of total plant feeding records. This pattern is in accordance with the report of Schulke et al. (2011) from Thailand; the diet of the macaque comprised more fruits i.e. 42.4% than leaves and flower.

In this study majority of fruits in the diet came from four tree species: *Castanopsis tribuloides, Syzygium cumini, Machilus duthiei* and *Choerospondias naxillaris* and the fruiting time for these plants is rainy and autumn seasons, as this study only includes data from rainy and autumn season so this may be the reason for the higher percentage of fruit consumption than other plant part. According to the Zhou et al. (2011) Assamese macaque ate more fruit when it was abundant in rainy season which supports result to this study. Autumn is the fruiting time for *Castanopsis tribuloides* which only accounts more than 29% of total plant feeding records, so we can infer that this is preferred food by Assamese macaque of Nagarjun forest. Availability of preferred food may have reduced the feeding events for other food items.

In China Zhou et al. (2011) found that tree species accounted for 93.2% of total feeding records for Assamese macaque followed by 3.1% for vine and 3.7% for herbs. In this study too greater proportion of food is fulfilled by tree species followed by vine, herbs and shrubs and they accounted for 69.56%, 13.04%, 8.69% and 8.69% respectively. Though the macaque forage on 28 tree species, only eight Species of tree such as *Castanopsis tribuloides, Syzygium cumini, Machilus duthiei, Betula alnoides, Choerospondias axillaris, Maclura conchinchinensis, Schima wallichii* and *Trichosanthes wallichiana* accounted for >3% each of all feeding records and contributed for 80.50 % of total plant diet during the study. Of these eight species, *Castanopsis tribuloides, Syzygium cumini* and *Machilus duthiei* accounted for 29.01%, 15.26% and 15.26% respectively of the total plant diet. It shows that the macaque is concentrated on a few species, but opportunistically consumed a large number of other plant species. Besides the plant species mentioned above other many food plants have been recorded during scan (Table 1). Other 14 food plants were recorded while macaques were feeding during

interval time between scan (Table 2). Invasive species *Lantana camara* have accounted for 1.52 % of total feeding records, its fruit and flower was eaten. A medicinal plant *Maclura cochinchinensis* accounted for more than 3% of feeding records, the vine has antimicrobial activity against gram-ve bacteria and anti dermatophytic activity (Kummee and Intaraksa 2008).

According to Schulke et al. (2011) Assamese macaque feeds on many vertebrate and invertebrate animals including mammals, birds, reptiles, amphibians, insects and mollusks etc. but during this study no any vertebrate feeding was recorded however feeding insects was recorded many times. Stone licking by an adult female was recorded during autumn supported by the result of Chalise (1999).

Feeding of primate is dependent on habitat quality, such as dietary quality, food abundance, distribution pattern of food plant and seasonal availability of food and they strongly influence the amount of time nonhuman primates spend in different activities (O'Brien and Kinnard 1997, Chalise 2000, Poulsen et al. 2001). The distribution of food resources in time and space may affect the social organization of primates too (Li et al. 2010).

Despite of having waste food in Fulbari Troop 'A' is found foraging on higher percentage of plant species than by Troop 'B'. *Castanopsis tribuloides* have greatest IVI i.e. 50.59 in Simpani area and this plant accounts for 29.01% of plant feeding records totally. According to Chalise (2000) the most utilization of dominant tree species lowered the number of food plant while non utilization of dominant species causes the increase of food plant number; in this case too this might be the reason for foraging on lower tree percentage by Troop 'B'.

IVI for the entire food tree were 206.4 and 203.4 for Fulbari and Simpani respectively. Among all trees highest IVI is of *Schima wallichii,* followed by *Machilus duthiei* and *Castanopsis tribuloides* in Fulbari i.e. 60.3, 47.4 and 25.8 respectively where as in Simpani highest IVI is of *Castanopsis tribuloides* followed by *Schima wallichii* and *Dodecadenia grandiflora* i.e. 50.6, 34.4 and 23.5 respectively. All the mentioned species accounted for more than 3% of feeding records in total except *Dodecadenia grandiflora* which is also a food plant. This result shows that both the habitat is good for the Macaques regarding dietary diversity.

Nature of distribution of food resource is the guiding force for allocating time to various activities and if food is randomly distributed Macaques group spent more time in feeding and locomotion (Sarkar et al. 2012). About 80% of food plants are patchily distributed in both the habitat and remaining is randomly distributed. Time spent by Assamese macaque in Nagarjun forest in feeding and foraging and moving activities is 38% and 22% respectively which is slightly less than study of Sarkar et al. (2012) in Jokai RF, Assam i.e. 40% and 25%. In Jokai RF food trees were randomly distributed but in present study most of the food plants are patchily distributed this may be the reason behind spending less time in feeding and locomotion behavior.

Conclusion

Assamese macaques of Nagarjun forest fulfill their demand for food mainly by two sources i.e. from plant species inside forest area and from the waste food from Army post. Besides this they are crop raider too. The food item selection is dependent on the availability of food source so the food items eaten by the two troops of macaque were significantly different. They are highly frugivorous unlike other previous study of macaque. Tree Species having highest IVI are the food plants of macaque in Nagarjun forest and IVI for all food trees more than 200 which shows that Nagarjun forest is good habitat for the macaques regarding food resource. Most of the food plants are patchily distributed in space; their distribution pattern is directly affecting the time spent in feeding and foraging behavior by macaque.

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