

**FEEDING BEHAVIOR OF SYMPATRIC RHESUS (*Macaca mulatta*
Zimmerman, 1780) AND ASSAMESE (*Macaca assamensis* McClelland,
1840) MONKEYS IN NAGARJUN FOREST, SHIVAPURI
NAGARJUN NATIONAL PARK, NEPAL**



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of Master of Science in Zoology with special paper Ecology

Submitted To

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February, 2017

DECLARATION

I hereby declare that the work presented in this thesis “Feeding behavior of sympatric Rhesus (*Macaca mulatta*) and Assamese (*Macaca assamensis*) monkeys in Nagarjun forest of Shivapuri nagarjun National Park, Nepal” has been done by myself and has not been submitted elsewhere for the award of any degree. All source of information have been specifically acknowledged by reference to the author(s) or institution(s).

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RECOMMENDATIONS

This is to recommend that the thesis entitled “Feeding behavior of sympatric Rhesus (*Macaca mulatta*) and Assamese (*Macaca assamensis*) monkeys in Nagarjun forest, Shivapuri Nagarjun National Park, Nepal” has been carried out by Anju Ghimire for the partial fulfillment of Master’s Degree of Science in Zoology with special paper Ecology. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LIST OF ABBREVIATIONS / ACRONYMS

Abbreviated form	Details of abbreviations
asl	Altitude from sea level
CAMP	Conservation Assessment and Management Plan
CITES	Convention on International Trade in Endangered Species of Wild And Fauna
CTA	Central Tibetan Administration
d.f.	Degrees of Freedom
DHM	Department of Hydrology and Meterology
DIIR	Department of Information and International Relations
DNA	Deoxyribonucleic Acid
GIS	Geographic Information System
GPS	Global Positioning System
IUCN	International Union for the Conservation of nature and Natural Resources
LNP	Langtang National Park
MBCA	Makalu Barun Conservation Area
mtDNA	MitochondrialDNA
RD	Relative Density
RF	Relative Frequency
ShNP	Shivapuri National Park
SNNP	Shivapuri Nagarjun National Park
T/HB	Tail to Head Body Ratio
VDCs	Village Development Committees
Yrs	Years

ABSTRACT

Feeding behavior of Sympatric Rhesus (*Macaca mulatta*) and Assamese (*Macaca assamensis*) Monkeys was studied on Nagarjun forest of Shivapuri Nagarjun National Park, Nepal. The study have been carried out from November 2015, to July 2016. Feeding behavior and food items of the monkeys were noted by scan sampling methods. Population of the studied troops were counted by direct counting of the individuals. Similarly quadrat method was used to analyze vegetation pattern of natural forest or monkey habitat.

The total population of studied troops was found to be 93 individuals monkeys of Rhesus and 149 individual of Assamese monkeys. Only two species of monkeys; the Rhesus and Assamese monkeys were recorded from Nagarjun forest. Mostly monkeys were encountered from the periphery of the forest near to human settlement areas and in Army canteen areas where they could get provisioned food easily. Moreover monkeys were also encountered from the natural forests where they completely fed on plant parts and their dependence on provisioned food was null.

During study it was recorded Rhesus monkeys fed on 72% on plants, 16% on crops, 9% of waste foods, and 3% on insects. Similarly Assamese monkeys fed on 67% on plants, 9% on crops, 19% on waste foods and 5% on insects. There was not significant difference in the food items consumed by Rhesus and Assamese macaques ($\chi^2=6.198$, $df=3$ p value <0.01). From the study frugivorous nature of macaque was recorded followed by folivorous nature where fruit constitute 48% for Rhesus and 51% for Assamese whereas leaf constitute 31% for Rhesus and 26% for Assamese. Macaques were also found feeding on leaf, flower, seeds and other parts of plants such as branches, twigs, shoot, seedlings, tubers and roots. There was not significant difference in the utilization of plant parts by the macaques during feeding time ($\chi^2=1.5$, $df=5$, p value <0.01). Similarly the study showed that Rhesus spent 49% of time on foraging/feeding, 29% on locomotion, 15% on rest or inactive and 7% on grooming whereas Assamese spent 44% time on foraging/feeding, 26% on locomotion, 19% on rest or inactive and 11% on grooming. Thus the study showed that Rhesus were active forager/feeder and locomoter than Assamese macaques. There was significant difference in the general behavior of Rhesus and Assamese macaques ($\chi^2=27.10$, $df=3$, p value <0.05). Rhesus fed on 41 plant species whereas Assamese fed on 39 plant species out of 46 plant species.

1. INTRODUCTION

1.1 General Background

Monkeys are included under the sub order Simiae of order Primate. Further Monkeys according to the geographical distribution are categorized into two types: new world monkeys and old world monkeys. The new world monkeys lack cheeks pouches and nostrils open two sides rather than down. Area between the nostrils is wide and flat. Most have long prehensile tail and non-have callous pads on the buttocks, e.g. Spider monkeys, Capuchins etc. The old world monkeys have protruded muzzle and well developed cheek pouches, nostril set close together facing forward and downward. The tail is never prehensile and some species are tail less. Both the hands and feet are adapted for grasping, callous pads on the buttocks are often bright and in case of females swollen during estrus period (Walker, 1968).

In Nepal, only three species of non-human primates (Hanuman Langur, Rhesus and Assamese Monkeys) are recorded (Chalise *et al.*, 2005). The Rhesus monkeys (*Macaca mulatta* Zimmermann, 1780) are found freely ranging in wild as well as in urban religious places. The Langurs (*Semnopithecus entellus* Dufresne, 1797) are found freely ranging in wild forest and its marginal areas of Nepal (Southwick *et al.*, 1982). The Assamese monkeys (*Macaca assamensis* Mc Clelland, 1840) are reported from mid-hills and high Mountain forest of Nepal (Chalise, 1999).

Three sub species of Assamese macaque have been reported until now and they are Eastern Assamese Macaque (*Macaca assamensis assamensis*), Western Assamese Macaque (*Macaca assamensis pelops*) And Assamese macaque ‘Nepal population’. The Assamese monkey of Nepal are considered ‘Nepal population’ and categorized as “Endangered” by CAMP Workshop 2003 due to taxonomic confusion and shrinking population in their typical natural habitat (Molur *et al.*, 2003).

Similarly Rhesus monkey (*Macaca mulata*) has well known four sub species. They are *Macaca mulatta mulatta* (Zimmerman, 1780), *Macaca mulatta vestita* (Milne-Edward, 1892), *Macaca mulatta villosa* (True, 1894), *Macaca mulatta memahoni* (Pocock, 1932).

1.1.1 Distribution

Assamese monkey inhabit in the mountains and hills along the Himalayas. It is recorded from Nepal, India (Mussoorie, assam), upper Burma, south China and north Thailand ranging 610 m to 1830 m asl (Fooden 1982). Himalayan form has longer tail then Indian one. In Nepal (Chalise, 2013) recorded it from 380 m in Mulghat Tamor to 2350m asl in Langtang. Mostly found in mid hills (warm temperate monsoon; cool temperate monsoon, 1000-3000m asl.) however they are recorded from lower elevation of 300m asl. Gorkha, Abukhaireni to Rimiche Langtang nearly 2500m asl. Assamese census was conducted in different occasion

revealed that 1099 individual in 51 troops are recorded from East Makalu to West Api area of Nepal (Chalise, 2013).

Rhesus monkey (*Macaca mulatta*) is also one of the best-known Simian species of family Cercopithecidae. They are distributed in South East Asia from northern Afghanistan in the east and south to the Godavari River in India, Thailand, Laos, Cambodia, Vietnam, Nepal, Bangladesh, Tibet and China in the west (Roonwal and Mohnot, 1977). It is most frequently kept in zoos even in smallest zoological gardens. Rhesus Monkeys are considered pest species by their nuisance behaviour. *M. mulatta* is likely the most adaptable to the wide variety of habitats and elevations, from high heat to snow fields to cities (Roonwal and Mohnot, 1977).

1.1.2 Morphology

The Assamese Macaque is also known as the Himalayan Macaque or the Hill Monkey. The Assamese Macaques pelt is dark to yellowish brown in color. The adult Macaque has red skin. The Assamese Macaques has hairless face cheek pouches to store food in while foraging. The Macaques body length measures from 50 to 73 centimeters (20 to 29 inches). The Assamese Macaques short tail is between 19 and 38 centimeters (7.5 to 15 inches) long, Himalayan form has longer tail than Indian one. The average body weight of the adult male Assamese Macaque is between 10 and 14.5 kilograms (22 to 32 pounds). The female weights between 8 and 12 kilograms (17 to 26 pounds) (Flannery, 2004).

An adult rhesus has a stoutly built body having medium size tail. The skin hangs in loose folds about the neck, breast and abdomen. They have pale face, fur is brown, olive brown and yellow brown no marked menstrual swelling is seen but large area of naked skin of buttock becomes red during fertile period (Pocock, 1975). Males have body length of about 48 – 68 cm whereas female rhesus measures about 45-55 cm in length. Similarly male weight 6.5 to 12 kg and female weigh about 5.49 to 7.37 kg (Chalise, 1997).

1.1.3 Population

Chalise (2013) estimated total population of Assamese macaque in Nepal to be 1,099 individuals in 51 troops in different habitat of mid-hills of Nepal. The isolated distribution of the Assamese macaque in Nepal seems insufficient for maintaining a viable population (Wada, 2005). Altogether 1966, Rhesus monkeys were recorded from the census of primate from Kathmandu and western part of Nepal. Similarly 816 langurs and 734 Assamese were recorded at the same time from same parts (Chalise, 2008).

1.1.4 General Behavior

Assamese macaque is diurnal, social animal living in hierarchical groups of 10 to 50 including both male and female (Environment and Development Desk, DIIR, CTA, 2005). They have subgroups of close kith and kin and stay closely during foraging, grooming and in night-rest in a troop. They are shy, timid and less aggressive to human beings in

comparison to rhesus monkey (Chalise *et al.*, 2005). They spent most of their time on feeding activity followed by moving (Chalise, 2003; Schulke *et al.*, 2011; Sarkar *et al.*, 2012).

Most social groups of Rhesus range from 8-180 individuals of both sexes. Rhesus monkeys are more aggressive in nature than Assamese. They are characterized by high degree of social flexibility. Four types of social groups can be described depending on the number of males in the group. They are one-male troop, multi-male troop, age-graded male troops, and all male band (Chalise, 2004b). Rhesus is ground feeder and is partly terrestrial and partly arboreal. Preferred foods include wild and cultivated fruits, berries, grains, leaves, buds, seeds, flowers and bark. They rest peacefully in mid canopy of trees to avoid their predation (Chalise, 1998).

1.1.5 Foraging/Feeding Behavior

All the primates have the same general need to acquire energy, amino acid, minerals, vitamins, water and certain fatty acids. However their specific requirements vary and are met in a great variety of ways (Oates, 1987). Sex differences in diet and foraging behavior have been reported in many non-human primate species. Females typically spend more time in foraging than co-specific males and feeds on more protein rich food (Rose, 1994).

Generally macaques have been described as primarily frugivorous (Yeager, 1996; O'Brien and Kinnaird, 1997; Riley, 2007) but regarding the case of Assamese macaque, they are omnivorous (Boonratana *et al.*, 2008) feeding on leaves, fruits, flowers, seeds, bark, shoot and caterpillar (Chalise, 2008; Chalise *et al.*, 2005) and other animal diet like mammals, birds, reptiles, amphibians, mollusks and spiders (Schulke *et al.*, 2011). Chalise (2003) and Zhou *et al.*, (2011) they are highly folivorous unlike other macaques. 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 and fruits (Chalise, 1999a, 1999b, 2003, 2010). Food selection of all monkeys depends upon the food habits, availability and content of required nutrients in the food items (Chalise, 2000). *Macaca mulatta* is a fast eater and has a well-developed collecting pouch in its cheek. Sometimes they also feed on insects, grubs, molluscs, and crustacean (Chalise, 1997).

1.1.6 Grooming

The monkeys search their fur or the fur of the other for lice or bugs or dirt which include rubbing, licking and scratching. The monkeys groom at the time of rest. In winter there are three peaks of grooming (Sade, 1965) There is auto grooming in which monkey searches its own body. The female monkeys are the most active groomer than the males. The grooming is found to be significantly higher during the mating season. Before and after copulation, the female starts grooming (Teas, 1978).

1.1.7 Moving and resting

Moving is the behavioral phenomenon in which monkey produces motion displacing from one place to another for various purposes.

Monkeys move especially for food. They move in their home range. The home range of primate is overlapped extensively or completely by similar or dissimilar species (Jolly, 1985).

Rhesus monkeys stayed in a relaxed posture with eyes closed. Resting is the state when the position of the Rhesus monkey in either sitting or lying with or without eye closed and not active into the other activities (Neville, 1968). Assamese rests with the body supporting upon the buttocks with hindquarters lowered on to a supporting surface. Generally macaque rests on the trees.

1.1.8 Conservation status

In Nepal, Assamese macaque is the only protected primate species protected under National Park and Wildlife Conservation Act 1973 (Chalise, 2010). It is classified as 'Near Threatened' world-wide by the IUCN Red List (Boonratana *et al.*, 2008). The species is also included in the CITES II (Molur *et al.*, 2003). 'Nepal population' of Assamese macaque is endemic in distribution due to localization only in Nepal (Molur *et al.*, 2003). It is classified as Endangered due to restricted distribution and scattered population of mature individuals (Molur *et al.*, 2003; Boonratana *et al.*, 2008). The assessment to the Rhesus monkey (*Macaca mulata*) was categorized as Least Concern as its abundance population and larger area distribution (Chalise *et al.*, 2005).

1.2 Objective of the study

1.2.1 General objectives

- To study the feeding behavior of sympatric Rhesus and Assamese monkey in Nagarjun forest, SNNP, Nepal.

1.2.2 Specific objectives

- To explore food items of Rhesus and Assamese macaques.
- To observe the general behavior of the macaques during study time of feeding behavior.

1.3 Rational of the study

Study of diet and behavior of a species is vital and foremost requirement 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, 1999b;

Gupta, 2005). Knowledge on diet is also an important factor to be considered when examining the relationship between ecology and socio-biological problems (Chalise, 2000).

Shivapuri Nagarjun National Park is near to Kathmandu. Though it's very near from urban area, only few people are aware about the presence of Assamese Macaque (Chalise *et al.*, 2013). Researches on feeding ecology and general behavior of Assamese macaque of Nepal has been carried out in natural habitat in Makalu- Barun National Park, Langtang National Park and Shivapuri forest of SNNP, Nagarjun forest of SNNP (Chalise, 2003; Chalise, 2010; Chalise *et al.*, 2013; Koirala, 2014), Similarly researches on Rhesus monkeys had been carried out on Bandhipokhari VDC area, Palpa, Shivapuri forest of SNNP, Nagarjun forest of SNNP (Ghimire, 2000; Bashyal, 2005; Rijal, 2015) but in Nagarjun forest a troop of Assamese and Rhesus macaque feeds on waste food from Army barrack area and other troops were found feeding naturally. The result of the research will be crucial to prepare effective management plans for this near threatened Assamese macaque and least concern Rhesus macaque in this protected area.

1.4 Limitation of the study

- The study area was extremely steep and slopy forest which created problems and the animal could not be followed continuously, at the time of scan sampling.
- The canopy coverage was found to be higher so it was difficult to observe, feeding behavior and difficult to identify food items when macaques spend their time on feeding at higher canopy even through binoculars.

2. LITERATURE REVIEW

Lindberg (1971) Rhesus monkey is considered as omnivorous in its feeding habits as it was reported to feed on eggs, termites and moulds in addition to plants. Similarly Lindberg observed variation in the daily activities cycles of the forests group of rhesus macaques with respect to the pattern frequency and intensity during the natural cycle of the warm-wet season (July-Oct), the cool season (Nov-Feb) and hot dry season (March-June).

Southwick *et al.*, (1982) and Chalise (1997). In Nepal, Rhesus monkeys are found in tropical rain forests of Terai to the valleys across of higher elevation of Makalu-Barun, Langtang and coniferous, alpine forest of Rara area too. They are in larger number in religious jungles and temples like Pashupati, Swayambhu, Sankhu, Bajrajogini etc. of Kathmandu valley (Chalise, 1998).

Simmen (1992) studied dietary differences permit species of the genera *Ateles* and *Alouatta* with similar body weights (e.g. 6-8 kg for *Ateles paniscus* and *Alouatta senoculus* to coexist). Spider monkeys (*Ateles* spp.) mainly eat ripe fruits, complemented by flowers and young leaves. Howler monkeys (*Alouatta* spp.) are much more folivorous, although their diet includes both ripe and unripe fruits. However, simultaneous utilization of the fruits of *Bagassa guianensis* Aublet (Moraceae), was observed with *A. paniscus* and *A. seniculus* during a part of rainy season in French Guiana. A detailed analysis of this dietary overlap reported two sympatric groups frequently fed on the same individual tree but select and utilize the different plant parts.

Rosenberg (1992) Diets primates are diverse which include ripe or unripe fruit, pulps and seeds as well as leaves, exudates and other plant parts or animals in various proportion. Similarly some studies that have been undertaken on the diet of Assamese macaques on the highlands of Nepal, Bhutan and India have concluded that they are primarily folivorous (Ahsan 1994, Chalise 2003, Srivastav 1999, Zhou *et al.* 2011).

Ungar (1996) gave the concept of the ecological niche to understand competition, natural selection and evolution in general. Feeding heights for 4 sympatric species of anthropoid primates *Hylobates larvesitus* (white-handed gibbons), *Macaca fascicularis fascicularis* (long-tailed macaques), *Pongo Pygmaeus abelii* (orangutans) and *Presbytis thoivimasi* (Thomas langurs) was reported. There were significant differences among species in preferred feeding heights and occurrences of terrestrial feeding. While these primates clearly differ in case of food preferences. Overlap in their diets (especially among the frugivores) suggested that height differences may also contribute to niche separation.

Sacco (1998) The ecologies of two sympatric primates, *Sanguinas fuscicollis* (Tamarin) and *Callicebus moloch* (Titi) were compared during a four month field study in Southeastern Peru. The examination of competition for food and space between these primates were found

to differ dramatically both in diet and in use of the shared habitat. Specifically Tamarins and Titis showed very little overlap in their choices of food plants or for animal prey. The resource competition between tamarin and titis was also found minimal.

Chalise (1999b) studied the behavior of Assamese macaques of Makalu-Barun Area, Nepal and find out that macaque spent 44% of time in foraging, 25% in moving, 13% in grooming and 18% time in resting

Bhattarai (2002) studied the general behavior and habitat utilization by Assamese macaque in Syafrubesi Area of LNP. He found that *Macaca assamensis* abundantly used broad-leaved conifer mixed forest and grassland with scattered trees of family Urticaceae. He recorded the time spent on sitting as highest as 33.3% followed by 29.6% on feeding, 28.2% on walking, 6.4% on grooming and 1.1% on mating.

Chalise (2003) studied body size, behavior and habitats of Assamese macaques (*Macaca assamensis*) in Nepal. He indicated some differences from the Assamese macaques of Makalu-Barun Area from those so far described from south-east Asia and suggested for the molecular genetic studies in order to resolve the taxonomic status.

Wada (2005) studied on distribution patterns of Assamese and Rhesus macaque in Nepal in 1984. During his survey he found that Rhesus macaque dominated the tropical, subtropical and temperate forests below 3,000 m asl all over Nepal; Assamese macaques were patchily distributed along rivers in the tropical and subtropical areas and both species principally utilized forest parapatrically. Discontinuous distribution of Assamese macaque was as a result of expansion of Rhesus monkey distribution in mid- and late- Pleistocene.

Kawamoto *et al.* (2006) studied the distribution of Assamese macaques in the inner Himalayan region of Bhutan mtDNA diversity. He recorded no groups of Rhesus macaques in his survey, in contrast with the survey results in the Nepalese Himalayas. He concluded that the macaques of the inner Himalayas regions in Bhutan are Assamese macaques and that they appear to be of a lineage distinction from Assamese macaques in the Indo-chinese region (subspecies *Macaca assamensis assamensis*). On the basis of degree of mtDNA diversity, he also concluded that the Assamese macaques in Bhutan are of a more ancient ancestry than *Macaca assamensis assamensis*. He suggested the earlier speciation of Assamese macaques on the basis of greater mtDNA diversity than that of Rhesus macaques.

Standford (2006) studied the behavioral ecology of the great apes. Chimpanzees and gorillas had been studied in detail in the wild and studies of their behavioral ecology in sympatry had also been carried out. Chimpanzee were a ripe fruit specialist whereas Gorillas in the same habitat also fed on ripe fruit when widely available but fall back onto fibrous plant foods during lean periods. The presence of animal protein in the diet of chimpanzees and its absence in that of the gorillas also distinguished the species ecologically.

Chalise (2010) studied on Assamese macaque of Sebrubeshi of Langtang National Park, he found that macaque in the area spent most of the time in forest followed by rocky slope; they spent their most of the time on feeding activity followed by moving. Maize, potato, rice, fruits and millet were the crop they damaged heavily in the area.

Grueter *et al.*, (2010) studied dietary and habitat requirement of two sympatric primate taxa, a “simple-stomached” and “complex-stomached” species (*Rhinopithecus bieti* vs *Macaca mulatta*). Both species showed a preference for fruits. While snub-nosed monkeys did not utilize any resources associated with human communities, rhesus macaques did occasionally raid agricultural crops. For both species, mixed deciduous broadleaf/conifer forest was the most frequently used ecotype, but whereas broad evergreen forest (Cyclobalanopsis community) accounted for only 3% . Groups of two species usually kept a considerable spatial distance from one another (mean 2.4km)..

Schulke *et al.*, (2011) studied about the ecology of Assamese macaque at Phu Khieo Wildlife Sanctuary, Thailand. They recorded that Assamese macaque spent large time on feeding fruit. They concluded that Assamese macaque spent about 40% of their activity time on the ground and in the lowest stratum of the forest; the canopy was used rarely and they spent a third of their activity time on feeding.

Zhou *et al.*, (2011) studied on diet of Assamese macaque in limestone seasonal rain forests at Nonggang Nature Reserve, China. They found that Assamese macaque are highly folivorous, where young leaf were staple food items (74.1% of the diet) and fruit accounted for only 17.4% of the diet.

Timmins and Duckworth (2011) studied about the distribution and habitat of Assamese macaque in Lao PDR; they made most of the record of Assamese macaque from hill evergreen forest above 500m and ecological overlap with Northern pig tailed macaque (*Macaca leonina*) and with Rhesus macaque (*Macaca mulatta*) is very limited in Lao PDR.

Sarkar *et al.*, (2012) have done quantitative analysis of activity budget of the forest group of Assamese macaque in Jokai reserved forest of Assam and found that the study group spent more than one third (40%) of their total annual time for foraging purpose, followed by 25% on locomotion, 13% on resting, 10% on grooming, 9% on monitoring, 1% on play and 2% on sexual and other activities. They have recorded distinct seasonal variation in activities pattern.

Regmi and Kandel (2013) estimated the group density of Assamese macaque in Lower Kanchenjunga Area, during which 35 observations of Assamese macaque were made. They found that macaque group encounter rate was 0.19521groups/km in the study area and estimated macaque group density was 1.2253 groups/km² with the expected group size

26.714. Similarly, the estimated population density and total number of macaques in the area were 32.733 and 1015.0 respectively.

Chalise *et al.*, (2013) studied on population, distribution and behavior of Assamese macaque in Shivapuri Nagarjun National Park. Seven bisexual troops of macaque were recorded near to human settlement areas with average troop size 23.71. They found that 46% of time is invested by the macaque in feeding activity followed by 19% in resting, 16% in locomotion, 12% in sleeping, 6% in grooming and 1% in playing behavior. Young leaves and twigs were primary source of food for winter.

Hessen *et al.*, (2013) investigated the relationship between food resources, feeding competition, energy intake and reproduction in a group of wild female Assamese macaques in northeastern Thailand and they found that an increase in food availability had a positive effect on female energy intake and conception rates.

3. MATERIALS AND METHODS

3.1 Materials

Following equipments were used during the field study.

- a) Binocular b) Measuring tape c) Digital Camera d) Data sheet
e) Topographic map of the study area f) Stationery g) GPS

3.1.1 Study area

The field study was carried out on Nagarjun forest of the Shivapuri Nagarjun National Park (SNNP). Shivapuri Nagarjun National Park is situated in the north of Kathmandu valley. It is nearest national park from Kathmandu, the capital city of Nepal. The park encompasses two separate forest patches viz:

Shivapuri and Nagarjun. the protected areas system of Nepal (SNNP, 2011).

Geographically, Shivapuri is located between 27° 45' to 27° 52' north latitude and 85° 16' to 85° 45' east longitude and Nagarjun is located between 27° 43' to 27° 46' north latitude and 85° 13' to 85° 18' east longitude. It is spread over Kathmandu, Nuwakot, Dhading and Sindhupalchok districts of Central Nepal. This is the true representation of the mid hills in Study area Nagarjun forest occupies an area of 16 km² at the border of Kathmandu, Dhading and Nuwakot Districts. Main range of the hill runs in the east west direction with the highest peak at Jamacho (2100 m asl), which rises abruptly from the floor of Kathmandu valley (1350m asl) (Pokhrel et al. 2011). Many spurs of the hill run in different direction forming gullies and narrow valleys. Previously Nagarjun was royal forest under Royal protection. In 2009, Nagarjun forest was included in Shivapuri National Park to provide extended habitat for wildlife population and as a representation of intact mid hill forest ecosystems whose representation is comparatively low in the protected area system of Nepal (SNNP 2011).

3.1.2 Climate

Nagarjun forest is typical Mahabharat hill and enjoys mostly sub-tropical type of climate and partly temperate climate with rainy summer and dry winter (Chaudhary, 1998). The southern side is sunny and evidently much drier than northern forest side.

The detail climatic data of the Nagarjun forest were not available others relevant data is from nearest metrological station at panipokhari, Kathmandu (27° 44'N latitude and 85°20'E longitude). The meteorological data of only, rainfall of Nagarjun station was available. The meteorological data of temperature, humidity and rainfall was mentioned of the year 2015 A.D. (Appendix I).

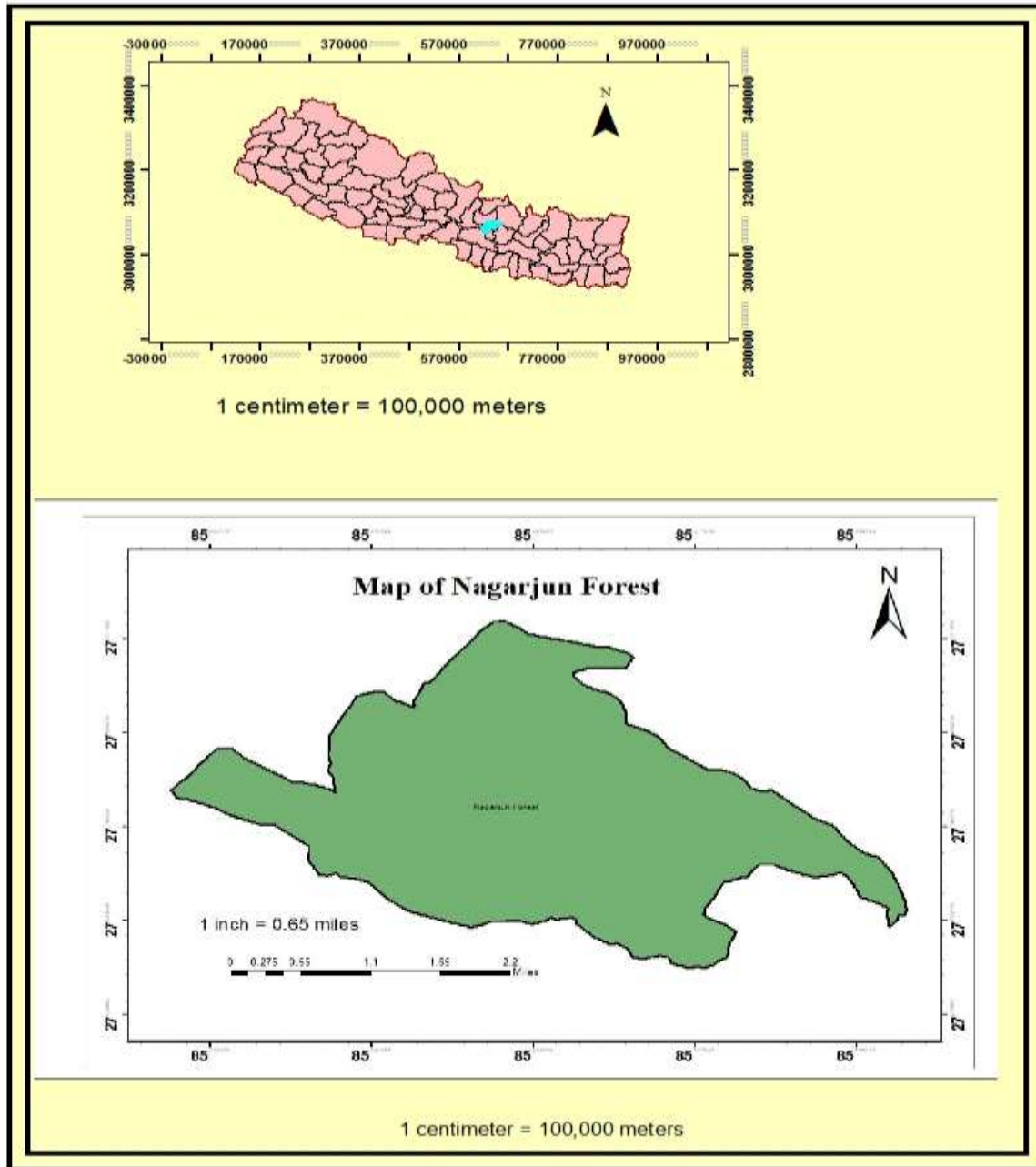


Figure 1. Map of Nagarjun forest of Shivapuri Nagarjun National Park, Kathmandu, Nepal

3.1.2.1 Temperature

Minimum Temperature

The meteorological data of 2015, at Panipokhari station minimum temperature ranges from 21.1⁰C (July) to 7.2⁰C (January) (Fig 2).

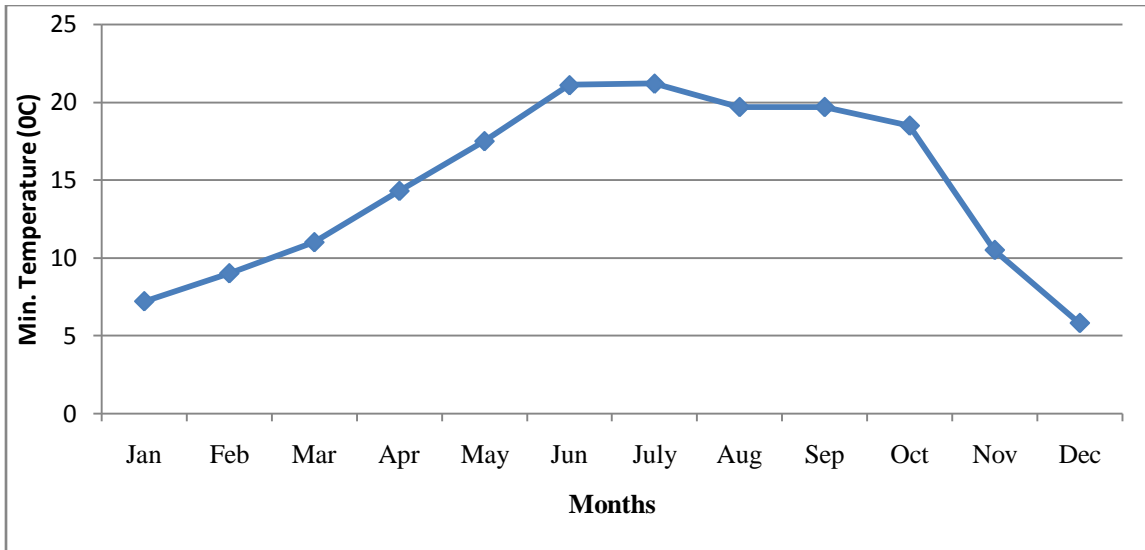


Figure 2. Minimum temperature recorded in 2015 at Panipokhari station (Source: DHM)

Maximum Temperature

The maximum temperature ranges from 21.1⁰C (January) to 32.2⁰C (June) (Fig 3). Thus maximum temperature reaches to 32.2⁰C and minimum temperature goes to 7.2⁰C on the year 2015 A.D. at Panipokhari station.

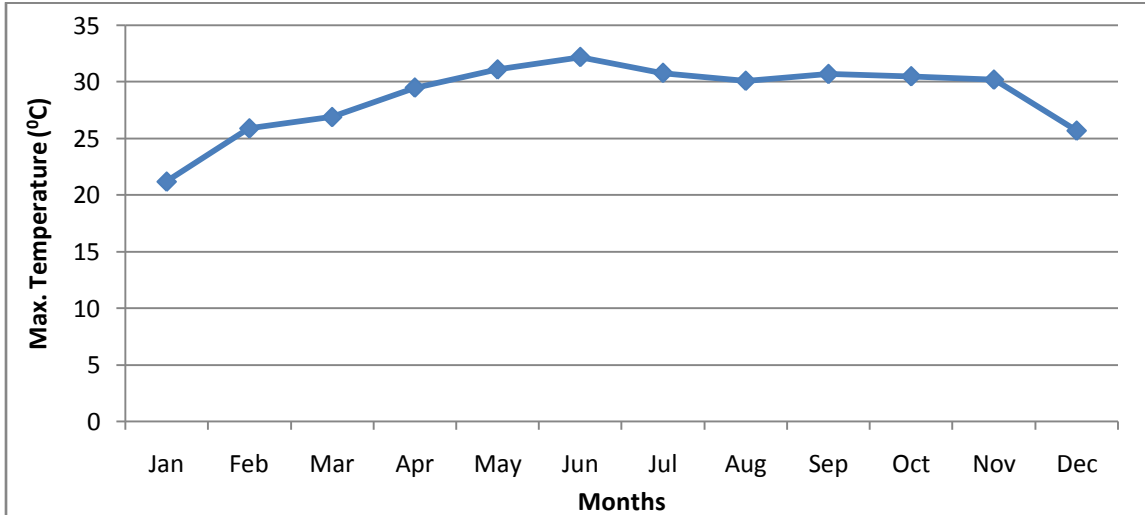


Figure 3. Maximum temperature recorded in 2015 at Panipokhari station (Source: DHM)

3.1.2.2 Humidity

Humidity is recorded at 8:45 AM and 17:45 PM. The relative humidity in the month of September was maximum (90.5%) at 17:45 pm. Similarly in the same month relative humidity was also recorded (90.4%) at 8:45 am. Minimum relative humidity was recorded (72.5%) at 17:45 pm in the month of January.

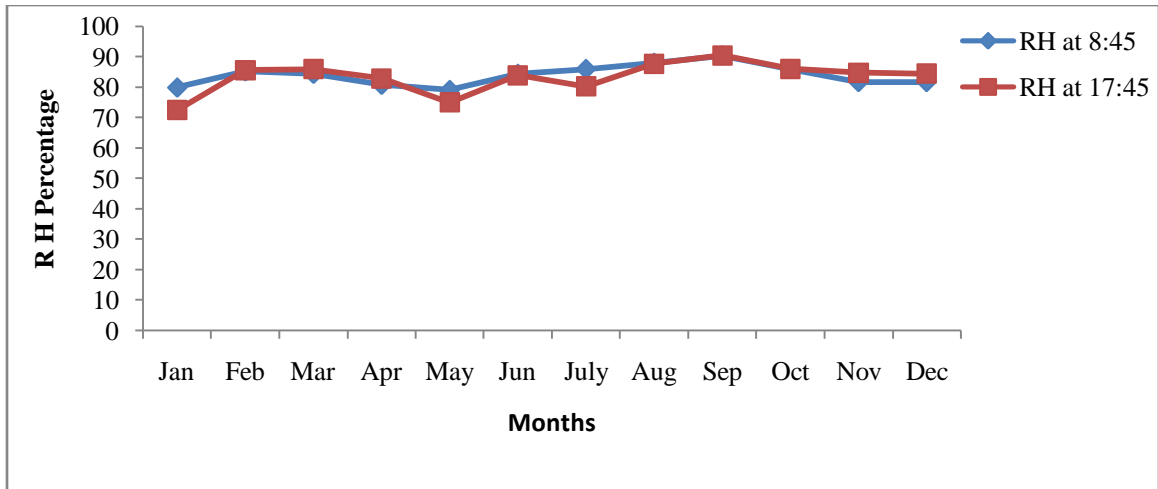


Figure 4. Humidity recorded in 2015 at panipokari station (Source: DHM)

3.1.2.4 Rainfall

The meteorological data of rainfall of the year 2015 was available of Nagarjun station. The rainfall was maximum 505.3 mm in the month of July and rainfall was minimum 5.5mm in the month of January at Nagarjun Station. The rainfall was not recorded in the month November and December (Fig 5). Similarly maximum rainfall 489.6mm in the month of July and minimum rainfall 13.8mm in the month of January was recorded from Panipokhari station. The rainfall at the month of November and December was also not recorded from Panipokhari station

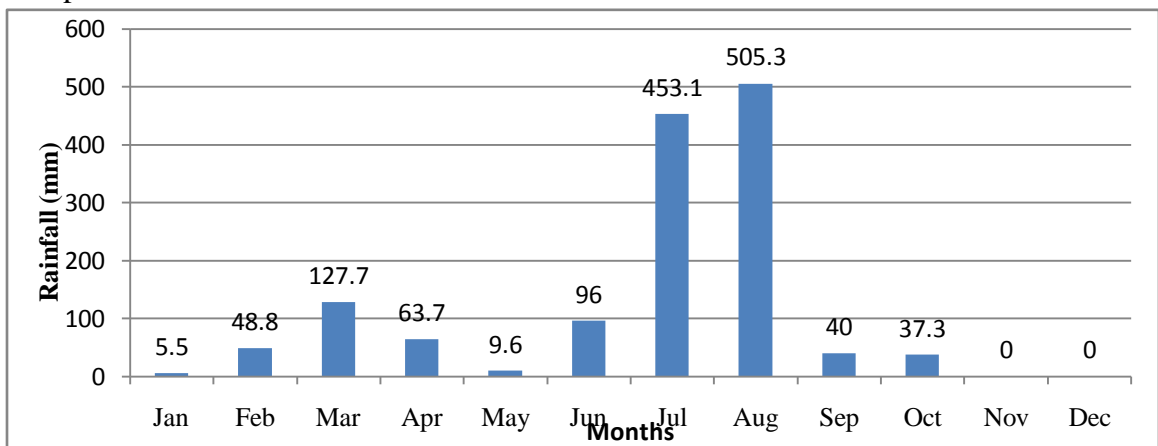


Figure 5. Rainfall (mm) in 2015 at Nagarjun station (Source: DHM)

3.1.3 Geology and soil

Geologically, Nagarjun forest falls under inner Himalayan Region. The soil found in Nagarjun forest is loosely arranged which is the main reason for soil erosion problems. Soil erosion and several small landslides can be observed at the time of continuous rainfall which even uprooted some plants. The Nagarjun forest largely consists of quartzite rock but also

consists of lime stone, siliceous limestone and calcisilicate rocks of uncertain age in certain extent (Hagen, 1959).

Topographically, Nagarjun forest is very steep having several slopy uplands. Soil composition of Nagarjun varies with different types of forest i.e. *Schima wallichii* forest consists of light blackish brown soil with some humus, mixed-broad leaf consists of humid light reddish brown to blackish soil with rich humus and pine forest consists of dry light brown to light brownish red soil without or with some humus (Kanai *et al.*, 1970).

3.1.4 Biodiversity

The study area is rich in biodiversity. The reason for this may be maximum protection achieved by this forest from security forces than any other protected areas in Kathmandu (SNNP, 2011). Nagarjun forest is totally protected and fenced and moreover it was Royal forest under Royal protection. It may be also another reason for biodiversity richness in this forest.

Shivapuri Nagarjun National Park lies in a transition between subtropical and temperate Zone, hence two isolated forest tracts of SNNP, Viz: Shivapuri and Nagarjun forest share diverse type of flora and fauna.

3.1.4.1 Flora

Forest in Nagarjun area mostly contains of mixed broad-leaved forests which can be categorized into four types: *Schima wallichii* forest, pineforest, mixed broadleaved forest (*Phoebe lanceolata*, *Machilus duthiei*, *Michelia kisopa* as major species) and dry oak forest (Kanai and Shakya 1970). Among the four types of forests recognized in Nagarjun hill, the *Schima wallichii*, forest constituted nearly 2/3rd of the total forest cover. *Schima wallichii* are distributed in almost all parts of the forest upto the altitude of 2100m (asl). GIS analysis has shown that coverage of *Schima wallichii* forest, mixed broadleaved forest, pine forest and dry oak forest in Nagarjun hill was 61.29%, 27.91%, 9.08% and 1.72%, respectively. There are few small patches of grassy meadow (Chalise *et al.*, 2013).

3.1.4.2 Fauna

Nagarjun forest is the habitat of many wildlife. It includes several species of mammalian fauna, many species of birds, 16 species of herpeto fauna including *Naja kaouthia*, *Ophiphagus hannah*, *Trimeresurus albolabris*, *Japulura variegata* are recorded from Nagarjun forest; among them *Megophrys parva* is most common among amphibians and *Calotes versicolor* is common among reptiles (Pokhrel *et al.*, 2011).

Many Bird species including Kalij Pheasant (*Lophura leucomelanos*), Yellownapes (*Picus* sps.), Barbets (*Megalaima* sps.), Green-billed Malkoha (*Phaenicophaeus tristis*), Owlets (*Glaucidium* sps.), Himalayan Griffon (*Gyps himalayensis*), Harriers (*Circus* sps.), Drongos (*Dicrurus* sps.) Thrush (*Monticola* sps and *Myophonus* sp.) Tits (*Parus* sps.), Nuthatch (*Sitta* sps.) Bulbul (*Hypsipetes* sps.), Laughing thrush (*Garrulax* sps.), Babbler (*Pomatorhinus* sps.)

and many species of wablers (Shrestha, 2001, Present study- Field Records using field guide for birds of Nepal (Grimmet *et al.*, 2003) are recorded inside Nagarjun forest.

Two species of macaques are recorded in Nagarjun forest that is Assamese macaque (*Macaca assamensis*) and Rhesus macaque (*Macaca mulata*) (Wada, 2005; Chalise *et al.*, 2013). Other mammalian fauna inside the forest includes bats (*Hipposideros armiger*, *Megaderma lyra*, *Miniopteros schreibersii*, *Rhinolophus affinis*, *Rhinolophus macrotis*, *Rhinolophus pusillus*) (Malla, 2000); Orange-bellied Himalayan squirrel (*Dremomys lokriah*), Squirrel (*Sciurus carolinensis*), Chinese Pangolin (*Manis pentadactyla*), Eurasian wild Boar (*Sus scrofa*), Barking Deer (*Muntiacus muntjak*) and Sambar Deer (*Rusa unicolor*) (Bhandari, 2013).

3.2 Methods

3.2.1 Preliminary survey

The preliminary survey was carried out from 15th November to 30th November 2015 in order to detect the likely areas of occurrence of Assamese and Rhesus macaque in the Nagarjun forest before the commencement of the field work. During the field work the information were collected through the discussion with the park authorities, park personals of the Nagarjun forest and local people.

The field was visited on foot. Several troops were encountered in Nagarjun forest during the preliminary survey. The macaques were observed using binoculars. From the encountered troops the feeding and general behaviors of the macaques were recorded through scan sampling (photo 5).

3.2.2 Data collection

The following methods were followed during the research work:

3.2.2.1 Population count of studied troops

During the study period population count of Assamese and Rhesus macaque was carried out in the Nagarjun forest. The populations of the macaques of the observed troops were counted. The path and roads were walked on foot and data of the observed monkeys were recorded in data collection sheet (Appendix II). Age-sex composition of macaques time, locality coordinates were also recorded at meanwhile. Voice recording was also done at the time of data collection.

3.2.2.2 Feeding and behavioral observation

Direct observation was done by following scan sampling and Adlibitum sampling methods to study the behavior of Rhesus and Assamese monkeys.

3.2.2.2.1 Scan sampling

The feeding behavior and general behavior of the Assamese and Rhesus macaque was taken by scan sampling (Altmann, 1974) method. The behaviors were recorded for one minute at intervals of 10 minutes. The scan sampling was carried out for about 169 hours and 51 minutes. The behavioral record was done for about 10-12 hours a day (7-8 AM to 5-6PM). Several types of instantaneous behaviors such as aggression, embrace, sex etc and state behaviors such as sleeping, inactive, locomotion, forage/eat, grooming, play etc were recorded. The activity of the troop at the time of scan was recorded (Appendix III). The food items consumed by the macaques were observed and noted. Binoculars and timers were also used to scan. Sometimes voice recording was also carried out.

3.2.2.2.2 Adlibitum sampling

This is a sampling technique in which additional information on rare events and on general occurrence (behaviors) in the troops noted down systematically (Chalise, 1995). Adlibitum sampling is informational observation which can be only used for descriptive purposes. Adlibitum sampling (Altmann 1974) also adopted to collect additional important information about food items, feeding habits and behaviors of the macaques.

3.2.2.3 Vegetation sampling

Random systematic sampling method was used for vegetation analysis (Singh *et al.* 2008). The walking trail was taken as the line transect. The quadrates were laid at the equidistance of 50m which was alternatively plotted on right and left side of the transect at Raniban and Mudkhu forest and army zone areas. Similarly from Jamacho the quadrates were taken at the equidistance of 100m upto Phulbari gate.

Altogether 20 quadrates of 15m×15m were plotted which contained several tree species and other vegetation. The local name of plants was identified by asking with experienced local persons. Photographs of unidentified plants were taken and asked with experienced person who was much more familiar with the plants.

3.3 Data analysis

Chi-square was used to test whether there is significant difference in feeding behavior of Assamese and rhesus macaques or not. Similarly to know the significant difference between basic basic food types of two troops. Chi-square was used for all statistical tests, $P < 0.05$ was considered for significant result.

$$\text{Chi-square } (\chi^2) = \frac{\sum(O-E)^2}{E}$$

Where O = Observed value

E = Expected value

4. RESULTS

4.1 Feeding behavior

4.1.1 Food items

Macaques were found feeding naturally on various plant species and some of the troops were found depending on the waste foods from Army canteen. Crop raiding was noticed and insect eating was also found. There was not significant difference in the food items consumed by Assamese and Rhesus macaques ($\chi^2=6.198$, $df=3$, $p < 0.01$).

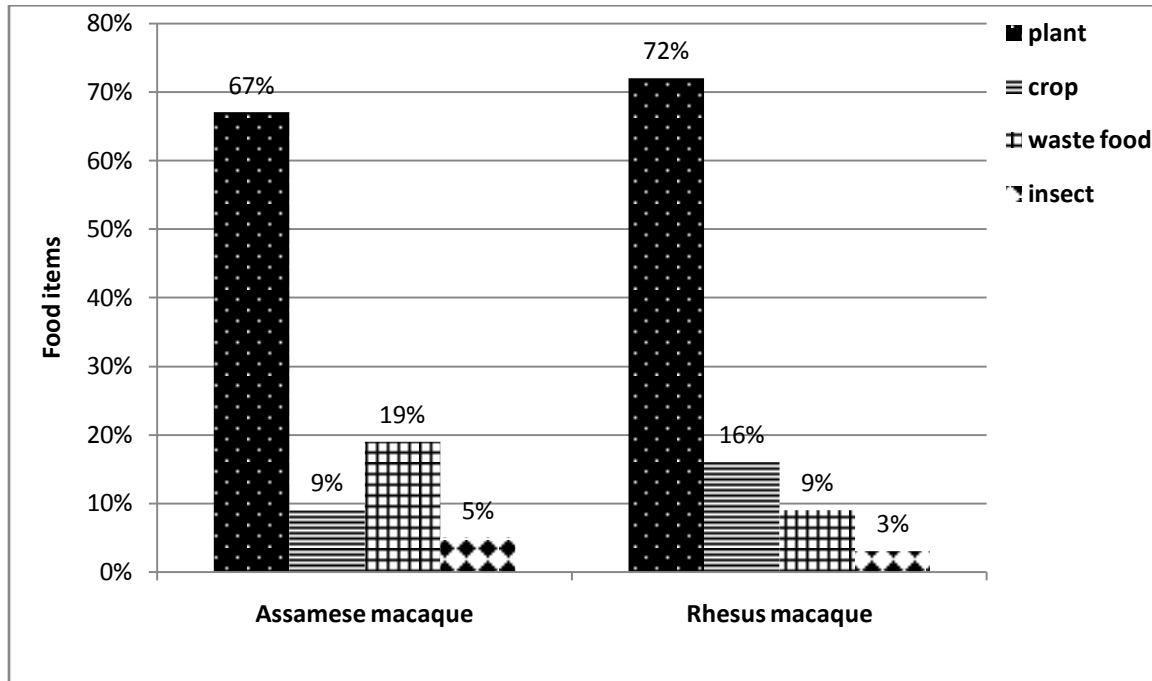


Figure 6. Food items taken by macaques and their percentage recorded in Nagarjun forest in SNNP during the study period.

4.1.2 Plant Parts consumed by monkeys

Plant diet composition showed that both the Assamese and Rhesus macaques of Nagarjun forest of SNNP were highly frugivorous followed by folivorous. Moreover macaques also fed on flowers seeds and other various parts of plants such as branches, twigs, shoot, seedlings, barks, rhizomes and tubers. There was not significant difference in the utilization of plant parts by the macaques during feeding time ($\chi^2=1.5$, $df=5$, $p \text{ value} < 0.05$).

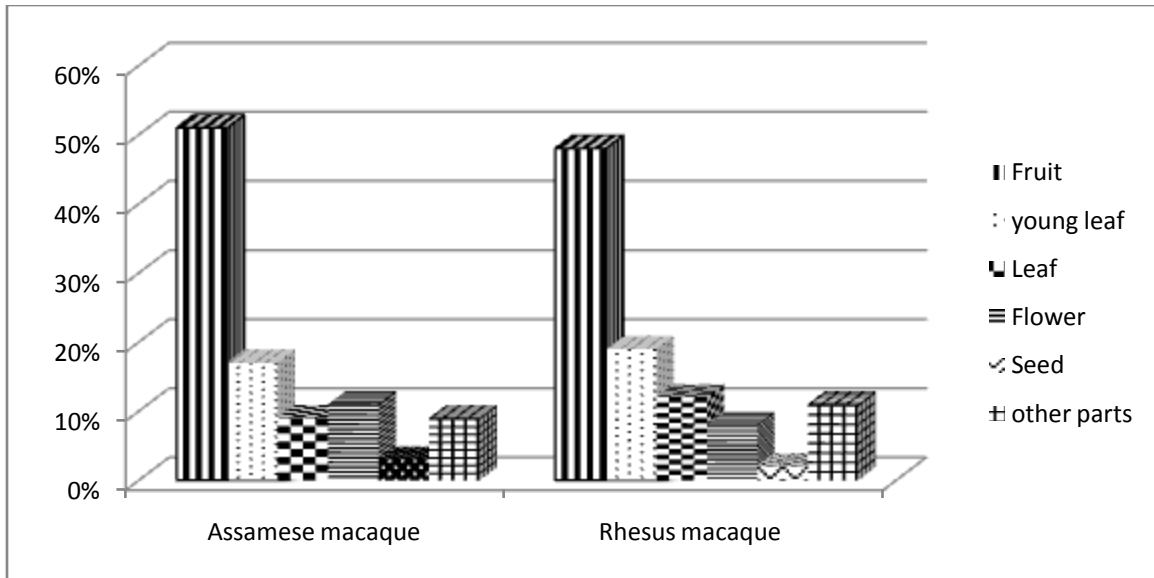


Figure 7. Plant diet composition and their percentage eaten by Assamese and Rhesus macaques in Nagarjun forest of SNNP during the study period.

4.1.3 Vegetation consumed by monkeys

Monkeys consumed 46 species of plants during my field visit where 31 species of plants were trees, 8 shrubs, 3 herbs and 4 climbers (Appendix IV). It showed that macaques feed on 67.39% on trees, 17.39% on shrubs, 6.52% on herbs and 8.69% on climbers.

Table 1. Plants consumed by Rhesus and Assamese monkey

SN	Local Name	Scientific Name	Life form	Rhesus monkey	Assamese monkey
1	Chilaune	<i>Schima wallichii</i> (DC.) Korth	Tree	✓	✓
2	Gobresalla	<i>Pinus wallichiana</i> A.B. Jacks	”	✓	✓
3	Hadekafal	<i>Myrica esculenta</i> Buch-Ham D.Don	”	✓	✓
4	Jure Kafal	<i>Eriobotrya dubai</i> (Lindl.) Decne	”	✓	✓
5	Gogan	<i>Sauraula nepaulensis</i>	”	×	✓
6	Musre katus	<i>Castanopsis tribuloides</i> (Sm.) A.DC.	”	✓	✓
7	Dhale katus	<i>Castanopsis indica</i> (Roxb.) Miq.	”	✓	✓
8	Khanayo	<i>Ficus semicardata</i> Buch-Ham.ex Sm	”	✓	✓
9	Phalat	<i>Quercus glauca</i> Thunb	”	✓	×
10	Firfire	<i>Acer oblongum</i>	”	✓	×
11	Mayal	<i>Pyrus pashia</i> Buch-Ham.ex Blume	”	✓	✓
12	Mahuwa	<i>Engelhardia spicata</i> Lesch.ex Blume	”	✓	✓

13	Hadebayar	<i>Zizyphus incurva</i>	”	✓	✓
14	Kalikath	<i>Myrsine semioserrata</i> Wall.	”	✓	✓
15	Setikath	<i>Myrsine capitellata</i> Wall.	”	×	✓
16	Lapsi	<i>Choerosporidias axiliaris</i> (Roxb.) B.L. Burtt & A.W. Hill	”	✓	✓
17	Jhigaini	<i>Eurya acuminata</i> DC.	”	×	✓
18	Saur	<i>Betula alnoides</i>	”	✓	✓
19	Angeri	<i>Lyonia ovalifolia</i> L.	”	✓	✓
20	Laligurans	<i>Rhododendron arboretum</i> Smith.	”	✓	✓
21	Jhankrikath	<i>Machilus duthieni</i> (Nees) Nees.	”	✓	✓
22	Lakuri	<i>Fraxinus floribunda</i> Wall.	”	✓	✓
23	Kutmero	<i>Litsea monopetala</i> (Roxb.) Pers	”	✓	✓
24	Painyau	<i>Prunus cerasoides</i> D.Don	”	✓	✓
25	Simal	<i>Bombax ceiba</i> L.	”	✓	✓
26	Jamun	<i>Syzygium cumini</i> (L.) Skeels	”	✓	✓
27	Pahele	<i>Dodecardenia grandiflora</i>	”	✓	✓
28	Nasi	<i>Stranvaesia nussia</i>	”	✓	×
29	Kapro	<i>Ficus lacor</i> (L.) J. Presl	”	✓	✓
30	Sanutusaro	<i>Colquhounia coccinea</i>	”	✓	✓
31	Peepal	<i>Ficus religiosa</i>	”	×	✓
32	Datiwan	<i>Achyranthus aspera</i> L.	Shrub	✓	✓
33	Aaiselu	<i>Rubus ellipticus</i> Sm.	”	✓	✓
34	Chutro	<i>Berberis asiatica</i> Roxb. Ex DC.	”	✓	✓
35	Masinokad a	<i>Lantana camara</i> L.	”	✓	✓
36	Ainjeru	<i>Scurrula parasitica</i>	”	✓	✓
37	Nigalo	<i>Arundinaria falcata</i> Nees.	”	✓	×
38	Bilaune	<i>Maesa chisia</i> Buch.-Ham.ex D.Don	”	✓	×
39	Amriso	<i>Thysanolaena maxima</i> (Roxb.) O. Kuntze	”	✓	×
40	Unyu	<i>Dryopteris filix-mas</i>	Herb	✓	✓
41	Neuro	<i>Dryopteris cochleata</i>	”	✓	✓
42	Kans	<i>Saccharum spontaneum</i>	”	✓	×
43	Unidentifie d		Clim ber	×	✓
44	Panilahara	<i>Tetrastigma serrulatum</i> (Roxb.) Planch	”	✓	✓
45	Indreni	<i>Trichosanthes wallichiana</i>	”	✓	✓
46	Gulfa	<i>Holboellia latifolia</i> Wall	”	✓	✓

Rhesus fed on 41 plant species whereas Assamese fed on 39 plant species out of 46 plant species. Rhesus were not found feeding on 5 plants species such as *Sauraula nepaulensis*, *Myrsine capitelatta*, *Eurya acuminata*, *Ficus relogiosa* and last one was unidentified climber. Similarly Assamese were not found feeding on 7 plant species such as *Quercus glauca*, *Acer oblongum*, *Stranvaesi anussia*, *Arundinaria falcata*, *Maesa chisia*, *Thysanolaena maxima* and *Saccharum spontaneum*.

Rhesus were not found feeding on 4 tree species and 1 climber. Similarly Assamese were not found feeding on 3 tree species, 3 shrub species and 1 herb during my study period. It showed that Rhesus fed on 27 tree species, 8 shrubs, 3 herbs and 3 climbers whereas Assamese fed on 28 tree species, 5 shrubs, 2 herbs and 4 climbers. The study showed there is not significant difference in plant species consumed by monkeys ($\chi^2=1.21$, $df=3$, P value <0.05).

4.1.4 Crop utilized and provisioned food

4.1.4.1 Crop utilized

During study period macaques were found feeding on crops too. Generally macaques fed on crops by raiding which were noticed by following the animal at the time of scan sampling.

Table 2. Crops and their parts utilized by Rhesus and Assamese monkeys.

SN	Name of crop	Scientific name	Plant/parts used
1.	Maize	<i>Zea mays</i>	Seed
2.	Peach	<i>Prunus persica</i>	Fruit
3.	Potato	<i>Solanum tuberosum</i>	Tuber
4.	Aalu bakhada	<i>Prunus communis</i>	Fruit
5.	Radish	<i>Rhaphamus sativus</i>	Root/leaf
6.	Apple	<i>Malus domestica</i>	Fruit
7.	Amba	<i>Psidium guajava</i>	Fruit

4.1.4.2 Provisioned food

One troop of Assamese macaque was found to be mostly dependent on provisioned food from Army canteen area. One troop of Rhesus was found to be partly dependent on the provisioned food. Sometimes macaques were fed by security personals too (photo 6). Provisioned food of Rhesus and Assamese Macaques in Nagarjun forest include the following items. Mostly the macaques feed on waste food i.e rice. Assamese Macaques depend more on waste food than Rhesus macaques.

- | | |
|----------------------|------------------|
| 1. Waste food (rice) | 2. Biscuits |
| 3. Noodles | 4. Bread |
| 5. Vegetables/fruits | 6. Gram and peas |

4.2 General behavior

It was found that Assamese macaque spent 44% of their total time on feeding 26% on locomotion, 19% on rest or inactive and 11% on grooming.

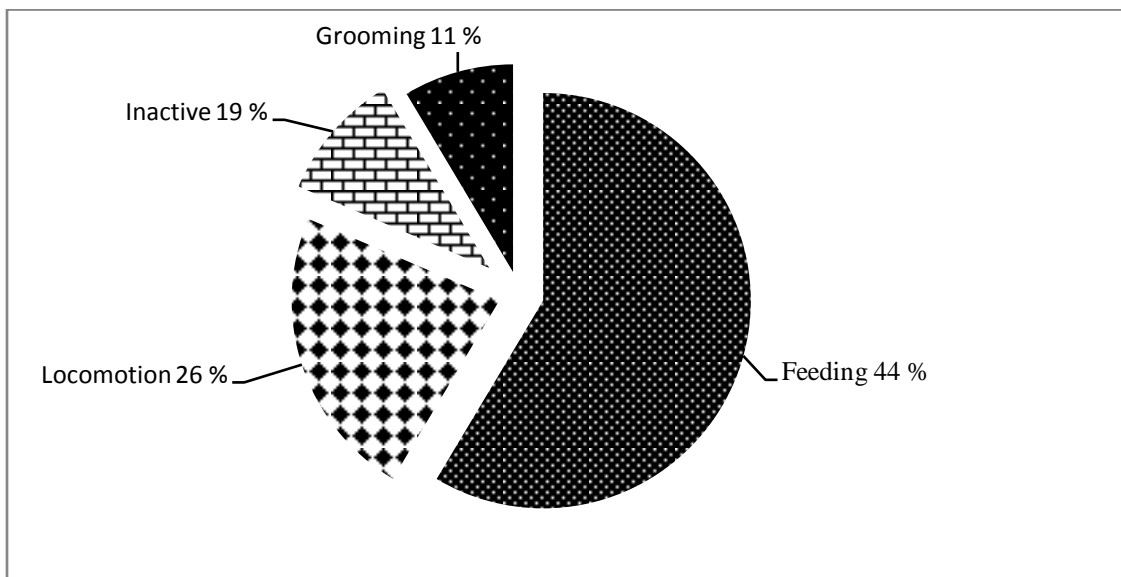


Figure 8. Percentage of time spent in major activities by Assamese monkeys in Nagarjun forest of SNNP during the study period.

Similarly Rhesus macaques spend 49% of their total time on foraging and feeding, 29% on locomotion, 15% on rest or inactive and 7% on grooming.

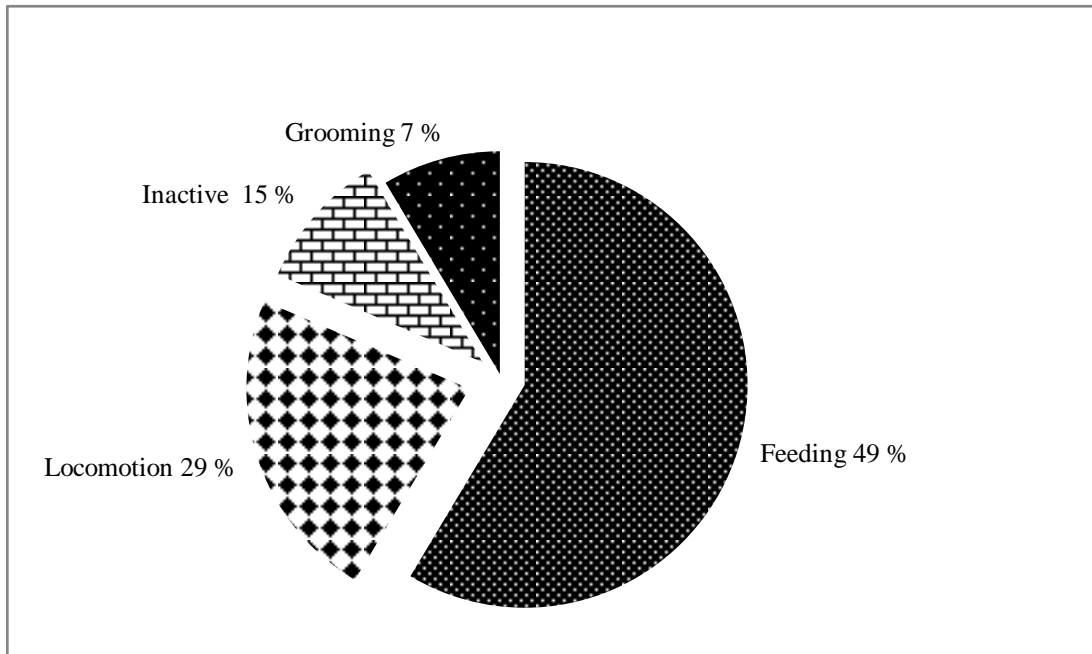


Figure 9. Percentage of time spent in major activities by Rhesus monkeys in Nagarjun forest of SNNP during the study period.

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and Assamese macaques. During the behavioral study of Assamese and Rhesus macaques it was found that Rhesus macaques spent their most of time on feeding than that of Assamese macaques. Since Rhesus macaques spent most time on so locomotion was also maximum in Rhesus macaques in comparison to Assamese macaques. Locomotion was mainly for searching of food. In Assamese macaques feeding and locomotion was less in comparison to Rhesus macaques so Assamese macaques were more inactive (rest) and spent more time on grooming than Rhesus macaques. There was significant difference in the general behavior of Rhesus and Assamese macaque in Nagarjun forest ($\chi^2 = 27.10$, $df=3$, $p < 0.05$).

4.2.1 Behavioral records from Adlibitum sampling

Some interesting behavior of the Rhesus and Assamese macaques were recorded through Adlibitum sampling; begging foods, drinking residues of beverages such as teas, coffees and cold drinks from cups and bottles, stone/mud licking, fighting, chasing, biting each other, infants playing like copulation, adults being ready for copulation after grooming, wearing caps, thieving eggs, fruits and vegetables from kitchen of army canteen, drinking oil residues from oil packets, mothers teaching small babies and infants to jump from one trees to another etc. Some of the behaviors of the macaques were influenced by stray dogs, visitors, rock climbers, hikers, trekkers, and security personals and illegally entered local peoples and so on.

4.3 Population count of studied troops

A total of 93 individuals of Rhesus macaques (*Macaca mulatta*) were observed in the study area (Appendix VI). Altogether 9 troops of Rhesus macaques were encountered. The maximum number of Rhesus was recorded from Mudkhu forest (29 individuals) whereas minimum number of Rhesus was recorded on the way to Jamacho where single individual was encountered.

A total of 149 individuals of Assamese macaques (*Macaca assamensis*) were counted in the study area (Appendix VII). Altogether 8 troops were encountered. The maximum number of Assamese was reported from the Army canteen area (38 in number) whereas minimum number of Assamese was reported from Syanagaun (9 in number).

5. DISCUSSION

5.1 Feeding ecology

Primates living in the wild spent as much as 65% of their time searching for obtaining processing and eating food (Clutton-Brock and Harvey, 1977; Wrangham, 1977; Malik and Southwick, 1988; Watts 1988). Macaque species have been described primarily frugivorous; (Riley, 2007). Tonkean macaque (*M tonkeana*) in Suwalesi, Indonesia showed that fruits accounted for 76.7% -84.4% of their diets. Feeding ecology of the black howler monkey (*Alouatta pigra*) in the Community Baboon Sanctuary in Northern Belize showed monkeys spent their time on fruits for 41% (Silver *et al.*, 1998). Similarly in the same study the black howler spent their time on feeding of foliage and flower for 45% and 11% respectively. The study on the diet of Assamese macaque of Nonggang National Nature Reserve; fruits accounted for only 20.1% of their diet. The Assamese macaques of this group was primarily folivorous where young leaves accounted for 75.5% and mature leaves accounted for 1.8% of their diet (Sacco, 1998). Hanya (2004) found that Japanese macaques (*M fuscata*) in coniferous forest of Yakushima spent their 45% of time on feeding leaves and 13% on feeding fruits. Hanya *et al.*, (2003) found variation in diet amongst Japanese macaques inhabiting different altitudinal zones. Much of these differences can be explained as differences in temporal availability and spatial distribution of fruit resources (Hanya *et al.*, 2003; Hanya, 2004). Different studies carried out on different monkeys on different region showed variation in the feeding ecology and diet composition of macaques. Variation in dietary composition and feeding ecology may be due to variation in vegetation with respect to geographical condition, geology, altitudinal ranges, climatic factors and other many reasons.

Koirala (2014) had reported that the Assamese macaques in Nagarjun forest were highly frugivorous where fruits constitute about 80.48% and leaves constitute about 13.60%. During my study the fruits consumed by Rhesus and Assamese monkeys were found to be 48% and 51%, leaves consumed accounted for 31% and 26% respectively. These two studies showed vast difference in the feeding items of the macaques. Koirala (2014) showed that the Assamese macaques were highly frugivorous, my study showed that Assamese and Rhesus macaques were highly frugivorous followed by folivorous. Koirala (2014) had conducted her research work during rainy and autumn season. Generally rainy and autumn seasons are the seasons when fruits get ripe so she had reported the highly frugivorous feeding behaviour of macaques. Above 50% of my field work was conducted during spring season so my study showed frugivorous as well as highly folivorous feeding pattern of macaques. Besides fruits and newly sprouted young leaves, flowers were also consumed by macaques which accounted 11% for Assamese and 8% for Rhesus.

5.1.1 Vegetation related to macaques feeding

The distribution of food resources in time and space may affect the social organization of primates (Li *et al.*, 2010). As the food is randomly distributed in the study area, individuals of primate do not able to monopolize the resources. So social tension due to aggregation is comparatively less in forest group as compared to provisioned or temple group (Sarkar, 2000). During vegetation sampling plants having diameter greater than 10 cm (Appendix V) was taken. 52 tree species were recorded where *Schima wallichii* was found highly dominant followed by *Castanopsis tribulatus* and *Machilus duthieni*. Relative density of plants were found to be 13, 10 and 9.8 respectively whereas relative frequency was found to be 11.39, 7.5 and 5.3 respectively. It showed that *Schima wallichii* was highly distributed in the study area (Appendix V)

Monkeys fed on 46 plant species where 31 species of plants were trees, 8 shrubs, 3 herbs and 4 climbers. Rhesus monkeys fed on 41 plant species where trees constitute 27 species, 8 shrubs, 3 herbs and 3 climbers whereas Assamese fed on 39 plant species where tree constitute 28 species, 5 shrubs, 2 herbs and 7 climbers. Rhesus were found feeding on hard parts of plant i.e shoot but Assamese were not found feeding on shoot during my study (Appendix IV). Furthermore Rhesus were not found feeding on 5 plant species whereas Assamese were not found feeding on 7 plant species.

5.1.2 Crops utilized and Provisioned food.

Monkeys fed on 7 species of crops during my study period (Table 2). They fed on crops by raiding which was noted by following monkeys. Mostly they fed on *Zea mays*, *Solanum tuberosum*, *Prunus communis*, and *Psidium guajava*. Provisioned foods include rice, bread, biscuit, vegetables/fruits, noodles, bitten rice, gram, peas etc.

5.2 General behavior

Behavior is the response of both the physical as well as habitat condition of animals. It varies from habitat to habitat depending upon resource distribution. In primate; food, mates, drink and roosting trees are the most important resources which control activities (Sarkar, 2000). General behavior of primate is generally categorized in five classes i.e feeding, foraging, resting, moving and social (which includes all grooming, playing, sexual behavior, vocalization and agonistic interactions) and these classes of category is generally used for the study of primate behavior (O'Brien and Kinnaird 1997, Riley 2007, Bowler and Bodmer 2011) but some primatologist have categorized four classes of behavior i.e feeding, moving, resting and social; foraging is included in feeding in this case (Caselli and setz 2011).

Chalise and Adhikari (2014), during study of general behavior of Assamese monkey at upper Marsyangdhi area, Lamjung; had categorized general behavior into four category viz; foraging, locomotion, resting and grooming. Feeding is included in foraging. I too follow the similar general behavioral pattern in my study in order to record the behavioral pattern of Rhesus and Assamese macaques of Nagarjun forest. Assamese macaques spent greater

percentage of time in feeding activities which was recorded as 45% (Chalise and Adhikari, 2014), 44% in MBCA (Chalise, 2003), 43.4% in LNP (Chalise, 2010). During my study Assamese macaques spent 44% of their time on feeding activity which is found to be similar with (Chalise 2003) in MBCA, and (Chalise 2010) in LNP which was 43.4%. Similarly in my study Rhesus were found to spent 49% of their time on feeding which was greater to that of Assamese macaques. It showed that Rhesus monkeys of Nagarjun were active feeder than Assamese. Koirala (2014) in Nagarjun forest had found Assamese macaques fed for 37.86%. Similarly Rijal (2015) recorded Assamese monkeys feed for 42% and Rhesus for 43% of their total time in the same Nagarjun forest. Bashyal (2005) found Rhesus macaques in Shivapuri feed for 38.4% which was quite similar to that of koirala (2014). Nepal (2005) and Ghimire (2000) from Bandhipokhari VDC area, Palpa reported 42.69% feeding behavior of Rhesus and 43.5% feeding behavior of Rhesus in Shivapuri respectively which were closer to my study of feeding behavior of Assamese. Similarly Sakha (1999) in Pashupati and Panthi (1997) in Swoyambhu recorded 24% and 17.13% respectively the feeding behavior of Rhesus. Both these behavior feeding is far less than that of natural feeding. It may be due to the provisioned food by the visitors and urban people.

The amount of time spent on locomotion is determined primarily by the distribution of food and food plant species in the habitat and by the nature of food items (Sarkar, 2000). Moreover locomotion found to be high followed by feeding behavior. Chalise and Adhikari (2014) recorded that Assamese spent 24% of time in locomotion. In my study Assamese spent 26% of time in locomotion and Rhesus spent 29% of their time on locomotion. Rhesus showed higher feeding behavior than Assamese so locomotion in Rhesus was also higher. Similarly Chalise (2010) recorded 31.7% of moving behavior from LNP. Rijal (2015) found both Rhesus and Assamese spent 25% of time on locomotion which was closely similar to locomotion of Assamese during my study. Bashyal (2005) found locomotion to be 24.93%. Koirala (2014) found 21.88% moving of macaques in Nagarjun. Comparing to study of Koirala, difference in locomotion was found, comparing locomotion of Rhesus of my study with the study of Bashyal and Rijal, locomotion was found high in my study. More locomotion shown by the monkeys may be for in search of food and due to uneven distribution pattern of food items in different seasonal basis. Ghimire (2000) and Nepal (2005) found locomotion of Rhesus 20.25% and 21.82% respectively. It may be due to similarity on geographical condition and vegetation pattern. Similarly Sakha (1999) and Panthi (1997) found locomotion of Rhesus 24% and 18.44% respectively from religious sites. Panthi reported very less moving behavior of Rhesus perhaps monkeys were more provisioned there.

Higher time spent in locomotion costs higher expenditure of energy. The Assamese monkeys which spent more time on locomotion had to spent more time on resting in order to make balance of energy demand and supply. Hence time spent by *Macaca assamensis* (13%, 9.13%, 31.2%) on resting was noted by (Sarkar *et al.*, 2012), (Chalise, 2000) and

(Aggimaragsee, 1992). Chalise and Adhikari (2014) found annual resting of Assamese monkeys to be 21%, Chalise (2010) found sitting for 18.5%. Koirala (2014) found 30.06% of resting. Rijal (2015) found both Assamese and Rhesus spent 25% of time in resting. In my study both the monkeys spent less time in resting than that of Rijal and Koirala; during my study monkeys showed more foraging/feeding and locomotion so resting was found to be less. Bashyal (2005) found 20% resting of Rhesus in SNNP whereas in my study Assamese spent 19% of time in resting which is closely similar to Bashyal and similarly Rhesus spent 15% of their time on resting. Nepal (2005) and Ghimire (2000) found resting of Rhesus 24.97% and 21.82% respectively. Similarly Sakha (1999) found resting 29% and Panthi (1997) found resting of Rhesus 14.56% which was similar to resting of Rhesus i.e 15% during my study.

Grooming behavior in long term serves the function of reducing 'social tension' (Schino *et al.*, 1988). and establishes a social bonding (Kurland, 1977) among the individuals within the group. Chalise and Adhikari (2014) found Assamese spent 10% of time in grooming which was quite similar to grooming of Assamese i.e 11%. Similarly Rhesus spent 7% of time in grooming which was quite similar to grooming behavior of Assamese recorded by (Aggimaragsee, 1992) which was 8%. Rijal (2015) found 11% grooming for Rhesus which was similar to grooming behavior of Assamese in my study. Similarly Rijal found Assamese spent 10% of grooming for Assamese which was also quite similar to grooming behavior of Assamese during my study. Bashyal (2005) found 16.18% grooming, quite similar to the grooming behavior of Assamese of my study. Sakha (1999) and Panthi (1997) recorded 16% and 15.36% grooming behavior respectively from religious sites which was found to be similar. The grooming as well as other behaviors of monkeys may be affected by climatic conditions, seasonal variation, location of study area, topography, vegetation, availability and distribution of food items and other many factors.

6. CONCLUSION AND RECOMMENDATIONS

During the study period in Nagarjun forest only two species of monkeys i.e Rhesus and Assamese monkeys were encountered. The study was conducted mainly on the feeding behavior of the monkeys. The number of Rhesus and Assamese monkeys were found to be 93 and 149 respectively.

Both the macaques were found feeding on fruits, leaves, young leaves, flowers, twigs, petioles, seeds, crops, insects, stone/mud licking, garbages thrown on roads and provisioned foods etc. Rhesus were found feeding on hard parts of plants too even semi-dry shoot but Assamese were found feeding mostly on the soft parts of the plants in comparison to Rhesus. Monkeys fed on 46 plant species where 31 species of plants were trees, 8 shrubs, 3 herbs and 4 climbers. Rhesus monkeys fed on 41 plant species where trees constitute 27 species, 8 shrubs, 3 herbs and 3 climbers whereas Assamese fed on 39 plant species where tree constitute 28 species, 5 shrubs, 2 herbs and 7 climbers.

The activities of Rhesus and Assamese Monkeys in Nagarjun forest were found to be similar. Both the macaque species spent their greater time on feeding followed by locomotion, resting and grooming.

Assamese macaques depend more on provisional food than Rhesus macaques in Nagarjun forest. Rhesus Macaques spent their more time on natural feeding than Assamese Macaque. Rhesus macaques consumed more crops than Assamese macaques. Crop was consumed by crop raiding.

During study period; interspecies overlapping was found. But their occurrence was not at same place at the same time.

Some recommendations put forwarded here, on the basis of study, for the effective management of the nationally protected Assamese Monkeys and least concerned Rhesus Monkeys in Nagarjun forest :

- Further research work should be conducted to explore the diet composition, seasonal variation in diet composition and utilization of vegetation all the year around.
- New saplings of frugivorous plants should be planted throughout the Nagarjun forests time to time so that macaques could get suitable and sufficient food items in near future.
- Visitors, rock climbers, and security personnels should be aware not to disturb the macaques. Stray dogs should be restricted to enter inside the park area.
- Illegal entry of local people inside the park for collection of fodder, firewood and other resources should be controlled.

- Wall damaged after earthquake should be properly maintained along with wired fence to avoid the illegal entry of strangers, visitors, addicts and stray dogs which could disturb the macaques.

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PHOTOPLATES



Picture 1. Female Assamese with its newly born Infant



Picture 2. Adult Rhesus in Army canteen area



Picture 3. Adult female Rhesus feeding on *Lantana camara*.



Picture 4. Adult male Assamese macaque.



Picture 5. Behavioral record during scan sampling.



Picture 6. Major of Army provisioning Rhesus macaques.

APPENDICES

Appendix I: Record of temperature, humidity and rainfall from panipokhari station and rainfall from Nagarjun station 2015.

Months	Panipokhari station 2015					Nagarjun station rainfall 2015	
	Temperature (°C)		Humidity		Rainfall (mm)	Months	(mm)
	Max	Min.	8:45am	17:45pm			
Jan	21.1	7.2	79.9	72.5	13.8	Jan	5.5
Feb	25.9	9.0	85.2	85.6	34.2	Feb	48.8
Mar	26.9	11.0	84.4	86.0	97.1	Mar	127.7
April	29.5	14.3	80.8	82.9	39.6	Apr	63.7
May	31.1	17.5	79.1	75.0	23.8	May	9.6
June	32.2	21.1	84.4	84.0	181.9	June	96
July	30.8	21.2	86.0	80.3	489.6	July	453.1
Aug	30.1	19.7	88.0	87.8	483.6	Aug	505.3
Sep	30.7	19.7	90.4	90.5	139.6	Sep	40
Oct	30.5	18.5	86.0	86.1	18.4	Oct	37.3
Nov	30.2	10.5	81.7	84.8	0.0	Nov	0
Dec	25.7	5.8	81.7	84.5	0.0	Dec	0

Appendix II: Data sheet to count population of encountered troops.

Place	GPS Point	Time	Age-sex composition of macaque				Total	Remarks
			AM	AF	J	I		

AM: Adult male, AF: Adult female, J: Juvenile, I: Infant

Appendix: III Data sheet used to scan general behaviors of Macaques.

Sheet No: _____ Troop :..... Date:.....

GPS location:..... Place:.....

SN	Time	General Behaviors				Remarks
		Forage/Feed	Locomotion	Inactive/Rest	Groom	

Appendix IV: List of plants and their parts consumed by Monkeys in Nagarjun forest.

SN	Local Name	Scientific Name	Life Form	Parts Eaten
1	Chilaune	<i>Schima wallichii</i> (DC.) Korth	Tree	Leaf, fruit
2	Gobresalla	<i>Pinus wallichiana</i> A.B. Jacks	Tree	Flower (cone)
3	Hadekafal	<i>Myrica esculenta</i> Buch-Ham D.Don	Tree	Fruit, seed
4	Jure Kafal	<i>Eriobotrya dubai</i> (Lindl.) Decne	Tree	Fruit,seed
5	Gogan	<i>Sauraula nepaulensis</i>	Tree	Fruit/flower/ leaf
6	Musre katus	<i>Castanopsis tribuloides</i> (Sm.) A.DC.	Tree	Young leaf/seed
7	Dhale katus	<i>Castanopsis indica</i> (Roxb.) Miq.	Tree	Flowers
8	Khanayo	<i>Ficus semicardata</i> Buch-Ham.ex Sm	Tree	Fruit
9	Phalat	<i>Quercus glauca</i> Thunb	Tree	Leaf
10	Firfire	<i>Acer oblongum</i>	Tree	Leaf
11	Mayal	<i>Pyrus pashia</i> Buch-Ham.ex Blume	Tree	Fruit/flower
12	Mahuwa	<i>Engelhardia spicata</i> Lesch.ex Blume	Tree	Fruit
13	Hadebayar	<i>Zizyphus incurva</i>	Tree	Fruit/flower
14	Kalikath	<i>Myrsine semioserrata</i> Wall.	Tree	Fruit
15	Setikath	<i>Myrsine capitellata</i> Wall.	Tree	Fruit/flower
16	Lapsi	<i>Choerosporidias axiliaris</i> (Roxb.) B.L. Burt & A.W. Hill	Tree	Fruit
17	Jhigaini	<i>Eurya acuminata</i> DC.	Tree	Young leaf
18	Saur	<i>Betula alnoides</i>	Tree	Leaf
19	Angeri	<i>Lyonia ovalifolia</i> L.	Tree	Fruit/flower
20	Laligurans	<i>Rhododendron arboretum</i> Smith.	Tree	Flower
21	Jhankrikath	<i>Machilus duthieni</i> (Nees) Nees	Tree	Fruit
22	Lakuri	<i>Fraxinus floribunda</i>	Tree	Young leaf
23	Kutmero	<i>Litsea monopetala</i> (Roxb.) Pers	Tree	Leaf
24	Painyau	<i>Prunus cerasoides</i> D.Don	Tree	Young leaf, leaf,fruit, seed

25	Simal	<i>Bombax ceiba</i> L.	Tree	Fruit,flower,bud
26	Jamun	<i>Syzgium cumini</i> (L.) Skeels	Tree	Fruit
27	Pahele	<i>Dodecardenia grandiflora</i>	Tree	Fruit, leaf
28	Nasi	<i>Stranvaesia nussia</i>	Tree	Leaf
29	Kapro	<i>Ficus lacor</i> (L.) J. Presl	Tree	leaf,bud,flower
30	Sanutusaro	<i>Colquhounia coccinea</i>	Tree	Young leaf, fruit
31	Peepal	<i>Ficus religiosa</i>	Tree	Leaf
32	Datiwan	<i>Achyranthus aspera</i> L.	Shrub	Fruit
33	Aaiselu	<i>Rubus ellipticus</i> Sm.	Shrub	Fruit
34	Chutro	<i>Berberis asiatica</i> Roxb. Ex DC.	Shrub	Flower
35	Masinokada	<i>Lantana camara</i> L.	Shrub	Fruit
36	Ainjeru	<i>Scurrula parasitica</i>	Shrub	Shoot
37	Nigalo	<i>Arundinaria falcata</i> Nees.	Shrub	Flower
38	Bilaune	<i>Maesa chisia</i> Buch.-Ham.ex D.Don	Shrub	Shoot
39	Amriso	<i>Thysanolaena maxima</i> (Roxb.) O. Kuntze	Shrub	New leaf
40	Unyu	<i>Dryopteris filix-mas</i>	Herb	Leaf
41	Neuro	<i>Dryopteris cochleata</i>	Herb	New leaf
42	Kans	<i>Saccharum spontaneum</i>	Herb	Leaf
43	Unidentified 'A'		Climber	Leaf
44	Panilahara	<i>Tetrastigma serrulatum</i> (Roxb.) Planch	Climber	Leaf
45	Indreni	<i>Trichosanthes wallichiana</i>	Climber	Fruit
46	Gulfa	<i>Holboellia latifolia</i> Wall	Climber	Leaf, fruit

Appendix V: Vegetation analysis of Nagarjun forest.

SN	Local Name	Scientific Name	Total	D	RD	F	RF
1	Chilaune	<i>Schima wallichli</i> (DC.) Korth	37	0.0082	13	75	11.39
2	Musurekatus	<i>Castonopsis tribuloides</i> (Sm.) A.D	31	0.0068	10	50	7.5
3	Jhankrikath	<i>Machilus duthieni</i> (Nees) Nees	28	0.0062	9.8	35	5.3
4	Phalant	<i>Quercus glauca</i> Thunb	15	0.0033	5.2	33	5.01
5	Setikath	<i>Myrsine capitellata</i> Wall	11	0.0024	3.8	25	3.79
6	Khari	<i>Celtis australia</i>	7	0.0015	2.3	15	2.27

7	Uttis	<i>Alnus nepalensis</i> D. Don	5	0.0011	1.7	15	2.27
8	Saur	<i>Betula alnoides</i>	7	0.0015	2.3	10	1.51
9	Phirphire	<i>Acer oblongum</i>	5	0.0011	1.7	10	1.51
10	Pahele	<i>Dodecardenia grandiflora</i>	2	0.00044	0.63	5	0.75
11	Banjh	<i>Quercus spp.</i> Sm	9	0.002	3.1	15	2.27
12	Payau	<i>Prunus cerasoides</i> D. Don	6	0.0013	2	15	2.27
13	Hadekafal	<i>Myria esculenta</i> Buch.-Ham.ex D. Don	5	0.0011	1.7	15	2.27
14	Jurekafal	<i>Eriobotrya dubia</i> (Lindl.) Decne	2	0.00044	0.63	5	0.75
15	Lakuri	<i>Fraxinus floribunda</i> Wall.	1	0.00022	0.34	5	0.75
16	Simal	<i>Bombaze ceiba</i> L.	2	0.00044	0.63	5	0.75
17	Arkhauloo	<i>Lithocarpus elegans</i> (Blume) Hatus. Ex Soep	4	0.00088	1.3	10	1.51
18	Lapsi	<i>Choerospondias axillaris</i> (Roxb.) B.L. Burtt & A.W. Hill.	5	0.0011	1.7	10	1.51
19	Gurans	<i>Rhododendron arboretum</i> Smith.	6	0.0013	2	15	2.27
20	Angeri	<i>Lyonia ovalifolia</i> (Wall) Drude	4	0.00088	1.3	15	2.27
21	Salla	<i>Pinus wallichiana</i> A.B.Jacks	13	0.0028	4.4	25	3.79
22	Kalikath	<i>Myrsine semiserrata</i> Wall.	3	0.00066	1	10	1.51
23	Peepal	<i>Ficus semicordata</i>	1	0.00022	0.34	5	0.75
24	Sanotusar o	<i>Colquhounia coccinea</i>	1	0.00022	0.34	5	0.75
25	Nasi	<i>Stranvaessia nussia</i>	1	0.00022	0.34	5	0.75
26	Kapro	<i>Ficas lacor</i> Buch.-Ham	2	0.00044	0.63	5	0.75
27	Jamun	<i>Syzygium cumini</i> (L) Skeels	2	0.00044	0.63	10	1.51
28	Jhigaino	<i>Eurya acuminate</i> DC.	1	0.00022	0.34	5	0.75
29	Mahuwa	<i>Engelhardia spicata</i> Lesch.ex Blume	9	0.0013	2	15	2.27
30	Mayal	<i>Pyrus pashia</i> Buch.-Ham. ex. D.Don	3	0.00066	1	10	1.51
31	Khanayo	<i>Ficus semicordata</i> Buch.-Ham.ex Sm	2	0.00044	0.63	10	1.51
32	Dhale katus	<i>Castanopsis indica</i> (Roxb.)Miq.	10	0.0022	3.5	25	3.79
33	Gogan	<i>Sauraula nepaulensis</i>	3	0.00066	1	10	1.51

34	Malato	<i>Macharantha spp.</i>	2	0.00044	0.63	10	1.51
35	Ranibhalayo	<i>Rhus succedonea</i> L.	1	0.00022	0.34	5	0.75
36	Bhakamilo	<i>Rhus javanica</i> L.	1	0.00022	0.34	5	0.75
37	Seto siris	<i>Albizia procera</i>	2	0.0044	0.63	10	1.51
38	Khiluwa	<i>Polygonatum species</i> Mill	1	0.00022	0.34	5	0.75
39	Khasru	<i>Quercus semecarpifolia</i> Sm	2	0.00044	0.63	10	1.51
40	Phaledo	<i>Erythrina stricta</i> Roxb.	1	0.00022	0.34	5	0.75
41	Dudhilo	<i>Ficus neriifolia</i> Var	1	0.00022	0.34	5	0.75
42	Kapoor	<i>Cinnamomum camphora</i> (L.) J. Presl	1	0.00022	0.34	5	0.75
43	Higuwa	<i>Camellia kissi</i> Wall.	2	0.00044	0.63	10	1.51
S	Koiralo	<i>Bauhunia purpurea</i> L.	1	0.00022	0.34	5	0.75
45	Bakle		2	0.00044	0.63	10	1.51
46	Jomanmandro	<i>Mahonia nepaulensis</i> DC.	1	0.00022	0.34	5	0.75
47	Aamala	<i>Phyllanthus emblica</i>	2	0.00044	0.63	10	1.51
48	Falamekanda	<i>Flacourtia spp</i> L'Her.	1	0.00022	0.34	5	0.75
49	Bakaino	<i>Melia azederach</i> L.	1	0.00022	0.34	5	0.75
50	Kutmiro	<i>Litsea monopetala</i> (Roxb.) Pers	3	0.00066	1	10	1.51
51	Asuro	<i>Justicia adhatoda</i>	3	0.00066	1	10	1.51
52	Dhupi		1	0.00022	0.34	5	0.75
	Total		319		100		100

D: density; RD: Relative density; F: Frequency; RF: Relative Frequency

Appendix VI : Population count of studied Rhesus troops .

Place	GPS location	Altitude (m)	Troop no.	Total number
Army Barrack	27 ⁰ 44'28.3"N 085 ⁰ 17'44.8"E	1464	1	11
Phulbari Gate	27 ⁰ 44'26.9"N 085 ⁰ 17'54.4"E	1336	1	14
Pani tank Area	27 ⁰ 44'08.0"N 085 ⁰ 18'0.6"E	1382	1	3
Goldhunga Area	27 ⁰ 44'54.2"N 085 ⁰ 18'0.6"E	1401	1	11

Raniban	27 ⁰ 44'22.2"N 085 ⁰ 18'27.4"E	1388	1	7
Way to Jamacho	27 ⁰ 44'38.6"N 085 ⁰ 17 28.9"E	1587	1	1
Mudkhu forest	27 ⁰ 45' 34.3"N 085 ⁰ 15'58.1"E	1558	1	29
Syanagaun	27 ⁰ 45'35.2"N 085 ⁰ 17'58.4"E	1527	1	14
Way to Raniban	27 ⁰ 44 20.8"N 085 ⁰ 17 43.4"E	1398	1	3
Total			93	

Appendix VII: Population count of studied Assamese troops .

Place	GPS location	Altitude (m)	Troop no.	Total number
Army canteen	27 ⁰ 44'28.5"N 085 ⁰ 17'44.8"E	1464	1	38
Phulbari	27 ⁰ 44'38.8"N 085 ⁰ 17'42"E	1381	1	21
Raniban	27 ⁰ 44'28.4"N 085 ⁰ 17'7.2"E	1356	1	19
Pachalivairab forest	27 ⁰ 44'21.1"N 085 ⁰ 16'48.5"E	1402	1	14
Way to Raniban	27 ⁰ 44'27.7"N 085 ⁰ 17'4.4"E	1376	1	14
Mudkhu forest A	27 ⁰ 45'33.7"N 085 ⁰ 15'58.2"E	1541	1	18
Mudkhu forest B	27 ⁰ 45'33.7"N 085 ⁰ 16'54.6"E	1431	1	16
Syanagaun	27 ⁰ 45'35.2"N 085 ⁰ 17'58.4"E	1529	1	9
Total				149