1. INTRODUCTION

1.1 General Background

Four species of monkeys have been reported from Nepal; Rhesus macaque (*Macaca mulatta*), Assamese macaque (*Macaca assamensis* McClelland 1940), Terai Grey Langur (*Semnopithecus hector*) and Nepal Grey Langur (*S. schistaceus*) (Molur et al. 2003). Among them Assamese macaque is one of the less common primate species and is explored patchily in Nepal (Chalise 2010).

Assamese macaque belongs to family Cercopithecidae and three subspecies of the macaque have been reported, they are: Eastern Assamese macaque (*Macaca assamensis assamensis*), Western Assamese macaque (*Macaca assamensis pelops*) and Assamese macaque "Nepal Population" (Molur et al. 2003).

The Assamese Macaque's pelt is dark to yellowish brown in color. The adult Macaque has red skin. The Assamese Macaque has a hairless face and cheek pouches to store food in while foraging. The Macaque's body length measures from 50 to 73 cm, tail is between 19 and 38 cm long and average body weight of the adult male Assamese Macaque is between 10 and 14.5 Kg while the female weighs between 8 and 12 Kg (Environment and Development Desk, DIIR, CTA, 2005).

The Assamese macaque is called Pahare Bandar in Nepali, Pupa in Rai and Thimnyau in Tamang dialect; other local dialect names are Kala Ganda and Missal (Chalise et al. 2005).

1.1.1 Distribution

Assamese macaque inhabits in the foothills of the Himalayas and adjoining mountain ranges in Southeast Asia (Hill and Bernstein 1969, Chalise 2003). This taxon occurs in Bangladesh, Bhutan, southwestern China (Guangxi, Guizhou, Tibet and Yunnan), northeastern India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Uttar Pradesh, and West Bengal), Lao PDR, Myanmar, Nepal, northwestern Thailand, and northern Viet Nam; it is found from central Nepal east into northern Myanmar and southeast through

southernmost China to the upper Mekong in Tibet, and in the east into southern Guizhou to Hoi Xuan in Viet Nam and Thateng in Lao PDR; the range continues south through the Myanmar/Thailand border ranges as far as Chongkrong, as well as to the Sunderbans in Bangladesh; There is a gap in northeastern India between the two main population pockets, specifically between central Bhutan and the south side of the Brahmaputra; the east bank of its upper course, the Dhibang, marks the division between the two subspecies (Boonratana et al. 2008).

In Nepal it has been recorded from 380 m to 2500 m asl (Chalise 2013). They were found along the Arun river at Apsuwa confluence, Bhumlingtar, Heluwabeshi; Bagmati river (Tapke Danda, Makawanpur), river basin of Trishuli, Kali, Sunkoshi, Gandaki, Karnali and in warmer valleys at higher elevation too. The species is confirmed from far-west in Kimni, Acham; Dadeldhura, Ramdi, Palpa; Beg Khola, Kali; Rasuwa and Helambu area, and from Godawari forests to Kathmandu city (Chalise et al. 2005, Chalise 2008).

Assamese macaque has been recorded from different protected areas of Nepal i.e. Langtang National Park (Molur et al. 2003, Regmi 2008, Chalise 2010), Shivapuri Nagarjun National Park (Wada 2005, Chalise et al. 2013); Makalu Barun National Park (Molur et al. 2003, Chalise 2003) and Annapurna conservation area (Chalise 2013).

Altogether they are distributed in east and west of mid hills of Nepal and were not recorded from Tarai plain and high snowy mountains and in human settlements (Chalise et al. 2005). In Nepal Assamese macaque has isolated distribution (Wada 2005).

1.1.2 Nepal Population

The Assamese monkeys of Nepal is designated as "Nepal Population" by the South Asian Primate Conservation Assessment and Management Plan Workshop in 2002 due to morphological variation from the existing two subspecies i.e. *Macaca assamensis assamensis* and *Macaca assamensis pelops*, based on their fur coloration, head body-tail length and its ratio size variation and weight (Molur et al. 2003). The 'Nepal Population' consists of overall darker fur color with fleshy pink face and the nasal area is darker than so far described population of this species (Chalise 2005). So the Assamese macaque of Nepal may be a new subspecies of Assamese monkey but needs further molecular genetic analysis to confirm taxonomic status

(Chalise 2003). Furthermore a distinct difference in color also has been found in macaques recorded in higher and lower elevations of the country; facial color is different in male and females; males are fleshy-yellow-white and females are pink-blood coloured. Pelage is tanned blackish-ashy to blonde-haires in both sexes (Chalise et al. 2005).

1.1.3 Habitat

Assamese macaque live primarily in subtropical broad leaf evergreen forests, and to a lesser extent, mixed deciduous and bamboo forest utilizing many types of forest vegetation from semi-deciduous mixed wet to tropical dry deciduous forest, from monsoon to tropical evergreen Montana forest (Timmins and Duckworth 2011). It prefers dense forest and does not usually occur in secondary forest (Boonratana et al. 2008). They spend great deal of time in the middle canopy (Molur et al. 2003), almost completely arboreal (Timmins and Duckworth 2011) and are rarely seen on the ground (Chalise 2010). But according to Schulke et al. (2011) they spent about 40% of their activity time on the ground and in the lowest stratum of the forest and rarely on the canopy.

'Nepal population' can be located in subtropical hill Sal forests areas to mixed deciduous forest, temperate broadleaved forest with rocky outcrops and along the riverside steep sloppy forests of above altitude (Molur et al. 2003).

1.1.4 Population

According to Chalise (2013) the estimated total population of Assamese macaque in Nepal was 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).

1.1.5 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).

1.1.6 Feeding behavior

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 2003, Chalise et al. 2005) and other animal diet like mammals, birds, reptiles, amphibians, mollusks and spiders (Schulke et al. 2011). According to 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).

1.1.7 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) but categorized as 'Vulnerable' in National Red List Series, Nepal (Jnawali et al. 2011). 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).

1.1.8 Threats

Nepalese Assamese macaque 'Nepal Population' faces conservation threats due to killing by farmers as a crop pest control measure (Chalise 1999a, 2010). Habitat destruction and

fragmentation due to rapid road building activities and hydropower projects; high dependency of local people on forest resources (firewood, fodder and wild fruits collection, intensive grazing and selective logging) (Wada 2005, Kandel 2009) forest fire and landslide (Molur et al. 2003) are the main prevailing threat for this species.

1.2 Objectives of the study

Investigation of feeding ecology of the Assamese macaque in Nagarjun forest of Shivapuri Nagarjun National Park is the main objective of the research. Specific objectives of the research are:

i. To find out the population of Assamese macaque in Nagarjun Forest.
ii. To observe the general behavior of the Assamese macaque in Nagarjun forest.
iii. To explore the vegetation associated with feeding of the monkey.

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) recorded three troops of Assamese macaque in Nagarjun forest and other three sites are given as potential sites of Assamese macaque according to interview. 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 Shivapuri-Nagarjun National Park (Chalise 2003, Chalise 2010, Chalise et al. 2013) but in Nagarjun forest a troop of macaque feeds on waste food from Army camp area, due to their feeding habit their behavior pattern may be different than previous studies but no any studies has been conducted to

study their behavior. So this study will explore the current status, feeding ecology and behavior of Assamese macaque and utilization of vegetation by them in the study area. The result of the research will be crucial to prepare effective management plans for this globally near threatened macaque in this protected area.

1.4 Limitations of the Study

i. Steep sloppy forest and rocky outcrops of the study area created difficulties to follow the animal continuously for long period.
ii. Heavy tourist flow, freely left domesticated dogs and security personals inside the park disturbed the research work.
iii. Food items consumed by the macaque were identified by direct observations. Since, they generally forage on middle or higher canopy, all the food items eaten by macaque couldn't be identified.
iv. It takes a long time to study feeding ecology and behavior, due to time constraint only rainy and autumn season's data were collected.

2. LITERATURE REVIEW

2.1. National Context

Non-human primates are not studied thoroughly in Nepal. Few researches have been carried out on behavior, ecology and population status of primates in different topographical region of Nepal. Among four primate species recorded in Nepal, Assamese macaque is least studied.

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 in subtropical forest of the national park and its marginal areas near to human settlement 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 burgeoning twigs were primary source of food for winter.

Regmi and Kandel (2013) estimated the group density of Assamese macaque in Lower Kanchenjungha 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/km^2 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 (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.

Regmi (2008) studied on the population status, threats and conservation measures of Assamese macaque in Langtang National Park. They recorded nine groups of Assamese macaque in the national park having adult sex ratio 1: 1.92. They found that maize, potato, wheat, buck wheat

and millet were the crop raided by Assamese macaque. Negative attitude of the farmers with respect to food security and habitat encroachment of Assamese macaque were the main threats for the species.

Khatiwada et al. (2007) studied the population status of Assamese macaque in Kathmandu, Rasuwa and Dhading districts. They found that the macaques were patchily distributed in the fragmented forests in these areas where macaques have been continuously facing the problem of habitat encroachment by the local people.

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.

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.

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 (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.

2.2 Global Context

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. In addition, it appeared that females incurred energetic costs during lactation and that females with a better physical condition during the mating season were more likely to conceive. Neither energy intake rates nor activity budgets were influenced by female dominance rank, even during periods when the levels of contest competition were predicted to be high.

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.

Schulke et al. (2011) studied about the ecology of Assamese macaque at Phu Khieo Wildlife Sanctuary, Thailand. Unlike Zhou et al. they recorded that Assamese macaque spent large time of feeding 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.

According to Ostner et al. (2008) the mating season was characterized by a general increase in aggressive behavior compared to the non-mating season and high dominance position is not associated with high costs in male Assamese macaques.

Kawamoto et al. (2006) studied the distribution of Assamese macaques in the Inner Himalayan region of Bhutan and their mtDNA diversity. He recorded no groups of rhesus macaques (*Macaca mullatta*) in his survey, in contrast with the survey results in the Nepalese Himalayas. He concluded that the macaques of the Inner Himalayan regions in Bhutan are Assamese macaques and that they appear to be of a lineage distinct from Assamese macaques in the Indo-Chinese region (subspecies *Macaca asaamensis 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 *M. a. assamensis*. He suggested the earlier speciation of Assamese macaques on the basis of greater mtDNA diversity than that of rhesus macaques.

Sinha et al. (2005) recorded a new species Arunachal macaque (*Macaca munzala*) from Western Arunchal Pradesh, Northeastern India which shares morphological characteristics independently with the Assamese macaque (*Macaca assamensis*) and with the Tibetan macaque (*Macaca thibetana*).

Cooper et al. (2005) studied the reconciliation and relationship quality on a group of Assamese macaques living near the Tukeswari temple near Goalpara, Assam, India. They found that females reconcile most often with valuable and compatible social partners.

Cooper and Bernstein (2002) studied the counter aggression and reconciliation in Assamese macaques living at the Tukeswari temple in the district of Goalpara in the state of Assam, India. They found that the proportion of agonistic episodes that involved counter aggression is relatively low and counter aggression, however, occurred more often among males than among females, and it is the most common when females initiated aggression against males. They reported that the frequency of reconciliation is low for fights among males and for fights among females, but reconciliation were particularly rare for opposite-sexed opponents.

Cooper and Bernstein (2000) studied the social grooming in Assamese macaques living on the Tukeswari temple grounds in Assam, India. They found in accordance with social bonding that females, as the long-term residents of this multifocal group, groom each other and juveniles more often than males groom one another or juveniles. They also reported that males groom females more often and for longer durations than females groom males and, whereas both males and females groom juveniles more often than juveniles groom them, juveniles groom their elders for longer durations.

According to Singh (2001) *Macaca assamensis* is second most common primate species, next to Rhesus, in Arunachal Pradesh; it is found in all type of forests including bamboo forests starring from the foothills to an altitude of 2,000m; the population of the macaque species in the state is under threat due to destruction and damage being caused to its habitat; the macaque is being hunted by the tribal people of the state for food and for medicinal purpose.

Cooper and Bernstein (1999) studied the Dominance in Assamese macaques at a temple site in Assam, India and constructed rank hierarchies for agonistic, grooming and mounting matrices. They found a nearly linear agonistic dominance hierarchy does not correlate with the directionality of mounting or grooming.

3. MATERIALS AND METHODS

3.1. Study area

3.1.1 Location

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. 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 the protected areas system of Nepal (SNNP 2011).

Study area Nagarjun forest occupies an area of 16 km^2 at the boarder 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. Geology and Soil

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). Soil composition of Nagarjun varies with different types of forest i.e. *Schima wallichii* forest consists of dry hard brown to blackish brown soil with less humus, dry oak forest consist of light blackish brown soil with some humus, mixed-broadleaf 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).

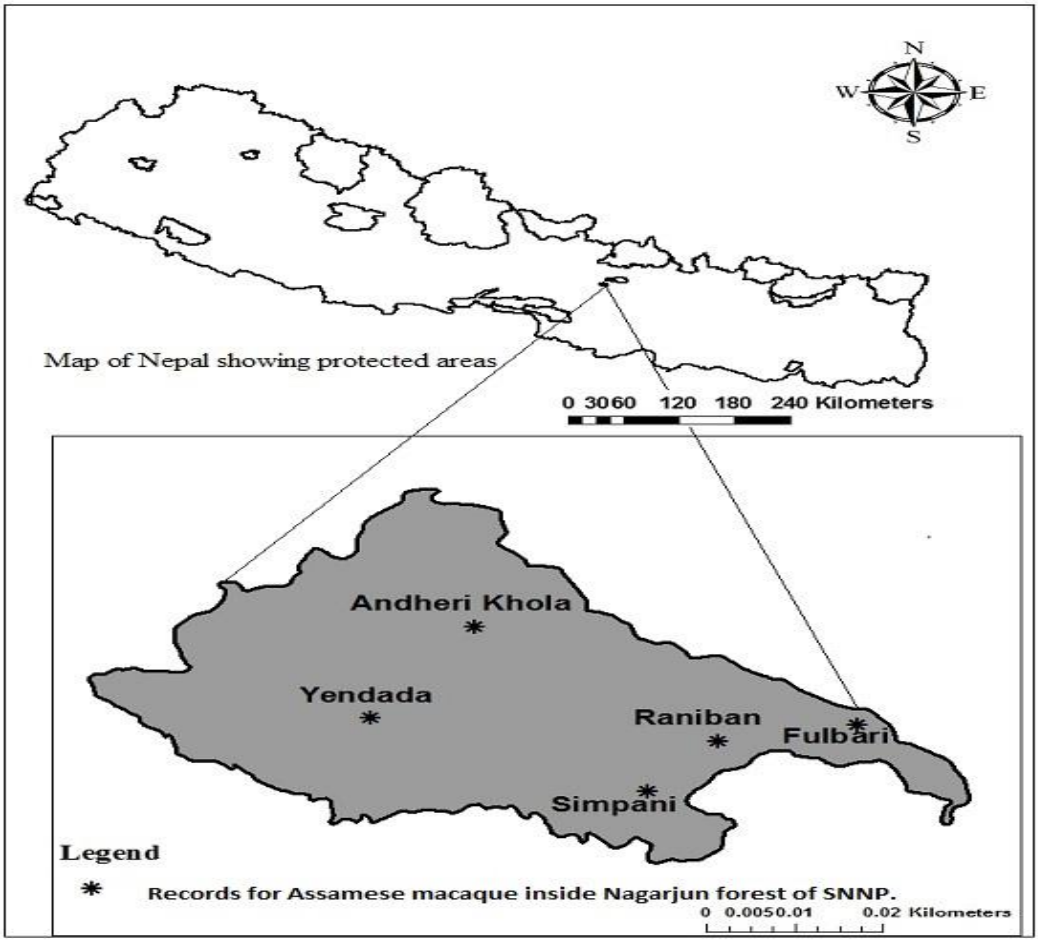

Figure 1: Map of Nagarjun forest of Shivapuri Nagarjun National Park with distribution of Assamese macaque.

3.1.3. Climate

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

The rainfall (mm) data for Nagarjun forest recorded at (27° 45" north latitude and 85°15" east longitude) was collected for 10yrs from 2002-2011A.D. There was no record of rainfall in the month of November for 10 yrs. The least average monthly Rainfall was recorded 3.43mm

(December) which ranged to 444.56mm (July) (Figure 2). July, August and September were the most precipitous months.

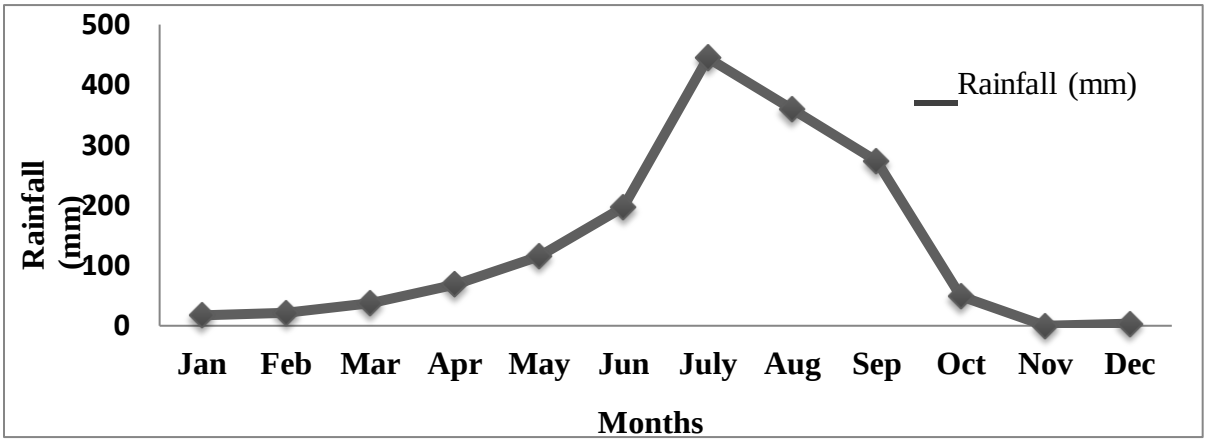

Figure 2: Monthly average rainfall of Nagarjun from 2002-2011A.D. (Source: Department of Hydrology and Meteorology 2013)

The climatic data of the Nagarjun area is not available. So, the nearest meteorological station at Panipokari, Kathmandu (27 ° 44”N and 85°20”E, and elevation at1335m) were used for analysis. The data was collected for 10 yrs (2002-2011A.D). According to the climatic data, 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) of the area ranges from78.73% (April) to 87.73% (September) (Figure 3).

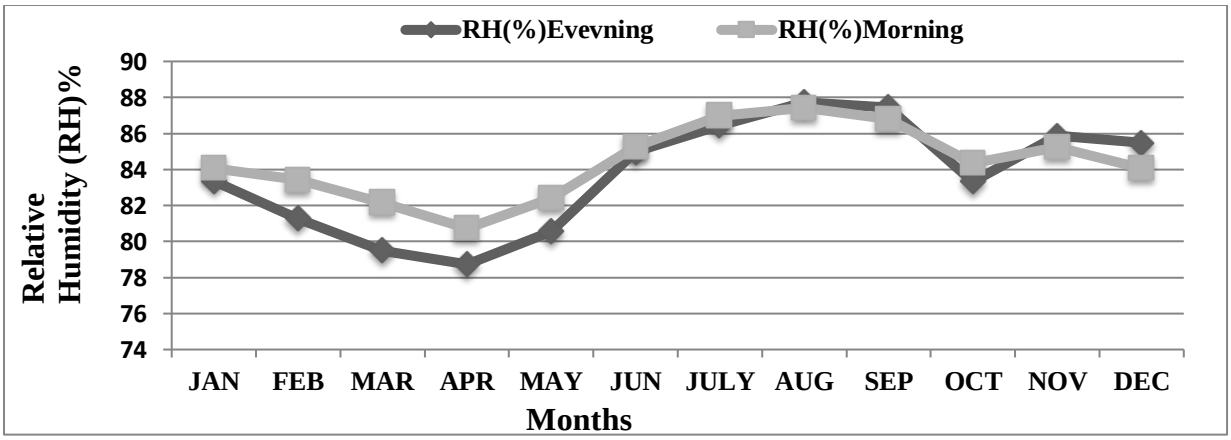

Figure 3: Monthly average Relative Humidity (RH) %of Nagarjun from 2002-2011A.D. (Source: Department of Hydrology and Meteorology 2013).

The mean monthly minimum temperatures of the area from 2002-2011 was recorded 3.9° C (January) to 20.35° C (July) and the mean monthly maximum temperatures of the area was recorded 18.63 ° C (January) to 29.56° C (Jun) (Figure 4). December, January and February were the coldest months while June, July and August were the hottest months.

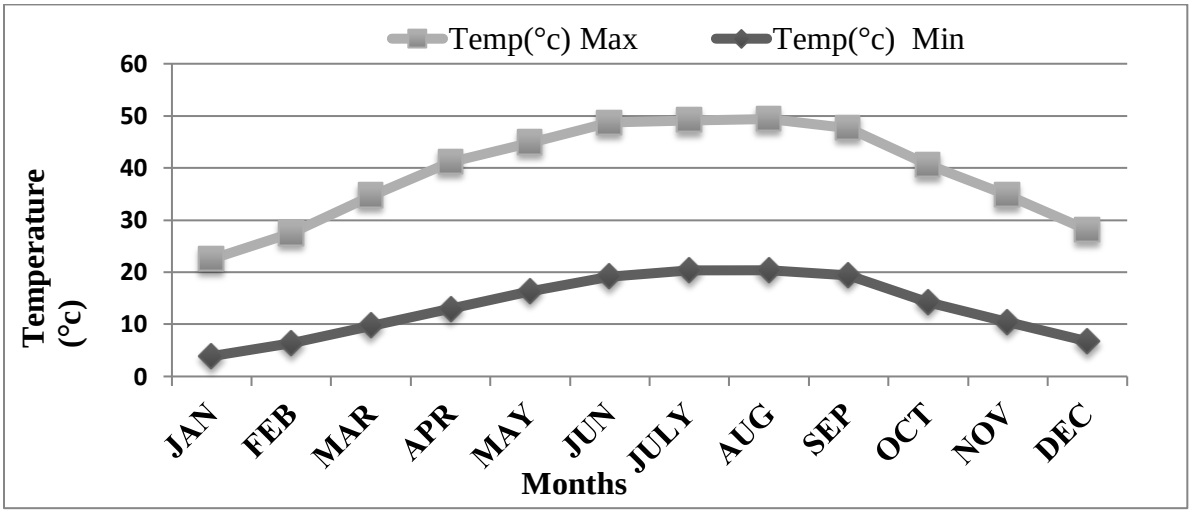

Figure 4: Monthly average Temperature of Nagarjun from 2002-2011 A.D. (Source: Department of Hydrology and Meteorology 2013)

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).

3.1.4.1. Flora

Forests in Nagarjun 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. 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 (Nagarkoti 2006).

3.1.4.2 Fauna

Sixteen species of herpetofauna including *Naja kaouthia, Ophiphagus hannah, Trimeresurus albolabris, Japulura variegate* 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 (*Pomatorhinu*s 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, Thapa et al. 2010); Orange-bellied Himalayan squirrel (*Dremomys lokriah*), Irrawaddy Squirrel (*Callosciurus pygerythrus*), Chinese Pangolin (*Manis pentadactyla*), Eurasian wild Boar (*Sus scrofa*), Barking Deer (*Muntiacus muntjak*) and Sambar Deer (*Cervus unicolor*) (Nagarkoti 2006, Bhandari 2013, Present study- Field Records using Field guide for wild mammals of Nepal (Baral and Shah 2008)).

3.2. Methods

3.2.1 Preliminary Survey

Preliminary survey was done from 15 May to 31 May 2012, to find out the likely areas of occurrence of Assamese macaque in the Nagarjun Forest before the commencement of detailed field work. The survey process included the collection of information through the discussion with the park authorities and security personnels of the SNNP and local people and the study area was visited on foot; animals were observed using binoculars.

Three troops were recorded in Nagarjun forest during the preliminary survey out of which two troops were selected for feeding and behavioral observations one from Fulbari and next form Simpani coded Troop ‘A’ and Troop ‘B’ respectively.

3.2.2 Data Collection

3.2.2.1 Population Count

Population count of Assamese macaque throughout the Nagarjun forest was carried out from all accessible roads in April 2013. The roads were walked slowly and the data of encountered macaques were recorded in data collection sheet (APPENDIX I): locality and its coordinates, detection time and age-sex composition of the group when possible. Age and sex of macaque was categorized as adult male, adult female, young, juvenile and infant using binoculars.

3.2.2.2 Feeding and Behavioral Observations

3.2.2.2.1. Scan sampling

Scan sampling (Altman 1974) was deployed for data collection of feeding and behavior study. 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 (APPENDIX II). Plant parts and other food items eaten by macaques were observed and noted. When an individual was feeding during moving and resting the behavior was recorded as feeding. Dependent infants were not sampled (O'Brien and Kinnaird 1997). Timer and binocular was used to scan.

3.2.2.2.2. Ad-libitum sampling

Ad-libitum sampling (Altman 1974) was adopted as well to collect additional important information about food items and behavior of the macaque continuously.

Day follow began when the group of animal first encountered and ended when the group settled in night settlement site or when the group was lost and could not be relocated. Data regarding feeding and behavioral observations were collected in rainy and autumn seasons in 2012.

3.2.2.3. Vegetation sampling

Random systemic sampling method was used for vegetation analysis (Singh et al. 2008). Two line transects of 500m were laid on both study sites; starting point for each transect were taken randomly and botanical quadrates of 10 x10m was alternatively plotted on right or left side of the transects at 10 m apart from the transect line. Distance between quadrates was 50m apart from one another. In each site, 22 quadrates were plotted in which tree species having diameter at breast height (DBH) $\geq$ 10cm was measured. Herbarium was prepared for identification of unidentified plant in the field and was identified at National Herbarium Center, Godawori, Lalitpur.

3.3 Data Analysis

The collected data was analyzed with the use of MS EXCEL 2007 and R- Software (R-Console version 2.15.2). Arc GIS 9.3 was also used to map out the distribution of Assamese macaque in the study area (Figure 1).

Chi-square was used to test whether the time spent in four categories of behavior varies according to time of a day or not; whether the time spent in different behavior varies according to season or troops or not. Similarly, to know the significant difference between basic food type of two troops and seasonal changes in food items Chi square was used. For all statistical tests, $p \leq .05$ was considered for significant result.

Birth ratio of the macaque is calculated by dividing total number of infants by total number of adult females (Chalise et al. 2013) similarly sex ratio is calculated by diving total number of adult male by total number of adult female (Chalise 2003).

Diversity of tree species was calculated using Shannon-Weaver Index using the formula:
$H' = -\sum Pi\ Log\ Pi$ where Pi is the proportion of the individuals belonging to the i^{th} species (Odum and Barrett 2005).

Important Value Index of trees were analyzed by using Zobel et al. (1987) where frequency, relative frequency, density, relative density, dominance and relative dominance were calculated to get important value index (IVI).i.e.,

IVI= relative frequency+ relative density+ relative dominance.

Density and relative density (RD):

$$\text{Density of a species} = \frac{\text{Total no. of individual of a species}}{\text{Total no. of quadrates sampled}} \times 100$$

$$\text{Relative density of a species} = \frac{\text{Total no. of individuals of species}}{\text{Total individuals of all species}} \times 100$$

Frequency and relative frequency (RF):

$$\text{Frequency of a species} = \frac{\text{No. of quadrat in which a species occured}}{\text{Total no. of quadrate sampled}} \times 100$$

$$\text{Relative frequency of a species} = \frac{\text{Frequency value of a species}}{\text{Total frequency value of all species}} \times 100$$

Relative dominance (ReD):

$$\text{Relative dominance of a species} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

Basal area of the species is a sum of the total of basal area of all trees of a species which was calculated using the following relation:-

$\text{Basal Area} = \pi\left(\frac{d}{2}\right)^2$ Where d= diameter at breast height.

The distribution patterns of macaque food plants was calculated by using Whitford's index, it is the ratio when abundance is divided by frequency; if the range of A/F value is <0.025, 0.025 to 0.05 and >0.05 represents regular, random and contagious distribution respectively (Singh et al. 2008).

$$\text{Abundance (A)} = \frac{\text{Total number of individuals of a species recorded in all quadrates}}{\text{Numuber of quadrates in which the species was present}}$$

$$\text{Frequency (F)} = \frac{\text{No. of sampling points at which sp. A occured at least once}}{\text{Total number of sampling points}} \times 100$$

4. RESULTS

4.1 Population

One hundred and thirty seven individuals of five troops of Assamese macaque were counted. The mean troop size was found to be 27.4 (Range 17-43) individuals. The group density was found to be 0.31 groups/km^2 and population density was 8.56 individuals/km^2.

Table 1: Population of Assamese macaque in different five troops in Nagarjun forest of SNNP.

Place	**Adult Female**	**Adult Male**	**Young**	**Juvenile**	**Infant**	**Total**	**Mean**	**Birth Rate**	**Sex ratio**
Fulbari	11	9	6	8	9	43	27.4	0.84	0.73
Raniban	5	3	1	3	5	17			
Simpani	10	7	6	7	8	38			
Yendada	Age Sex could not categorized					21			
Andheri khola	Age Sex could not categorized					18			
Total	26	19	13	18	22	137			

Among the five troop of macaque Troop of Fulbari i.e. Troop 'A' was the largest group recorded and the troop was depended on waste food of Army barak area; next troop of Raniban was also found to be a visitor to Army Post of Raniban for waste food where as other troops were not observed feeding on waste food during study. As the troop of Fulbari i.e. Troop 'A' and Troop of Simpani i.e. troop 'B' were selected for behavior study after habituation so age sex was categorized for all individuals of the troop. Troop recorded in Raniban was encountered while moving towards night settlement site so age sex was categorized easily. But for rest of the two troops total individuals only were counted because of their wild nature and they were encountered only once during whole study period. Troops recorded from Fulbari and Raniban utilize rocky outcrops as night settlement site.

Four age groups were identified as infants, juvenile, young and adult (male and female) from three troops. There were 22.45% infants, 18.37% juvenile, 13.26% young, 19.39% adult male and 26.53% adult females (Table 1). The adult sex ratio (male: female) from age sex group separated troops was 0.73. Each female had 0.84 infants during the study.

4.2 General behavior

Altogether, 1051 events were recorded from the scan sampling among which 398 events were recorded as feeding (foraging, feeding and resting chewing food) which is 37.86 % of the total behavioral activities. Similarly, 316 events were recorded as resting, 230 events as moving and 107 events as social behavior (grooming, playing, aggression and sexual behavior) which is 30.06%, 21.88% and 10.18% respectively of the total behavioral records.

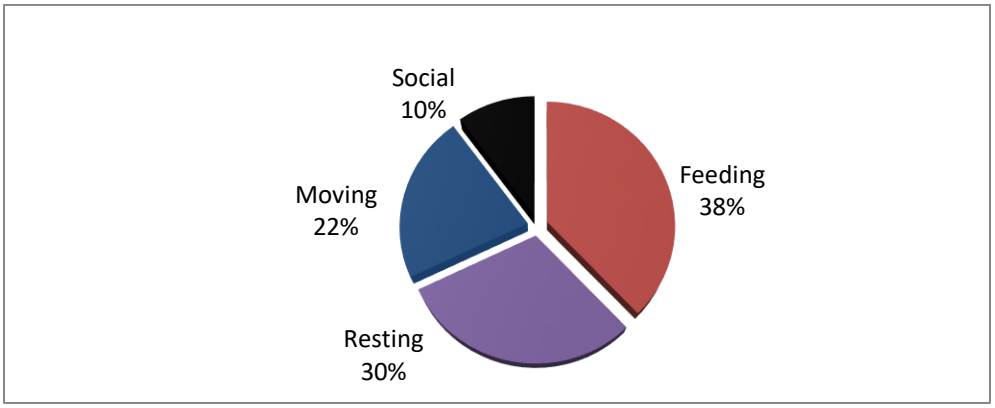

Figure 5: Percentage of time spent in major activities by Assamese macaque in Nagarjun forest of SNNP in 2012.

4.2.1 Behavior pattern according to time period of day

Time of day was categorized in four periods i.e. 6 am to 9 am, 9am to 12 noon, 12 noon to 3 pm and 3 pm to 6 pm and the collected data were tested either the time spent by the macaques in different behavior varies between the four periods of a day or not and found out that macaques does not spent equal time in four major behaviors during the four time periods of the day (χ^2 = 47.24, df = 9, p value < 0.001). Time spent on feeding and foraging behavior is recorded highest during 12 noon to 15 pm among the four periods i.e. 46% and lowest is during 15pm to 18pm i.e. 33%. Time spent on moving is too highest during 12 pm -15 pm i.e. 29% and lowest percentage of time spent on moving is during 9am – 12noon i.e. 15%. During 12 noon – 15 pm macaques

spent greater percentage of time on feeding and moving behavior so the time spent in resting and social behavior is lowest than other period i.e. 19% and 6% respectively.

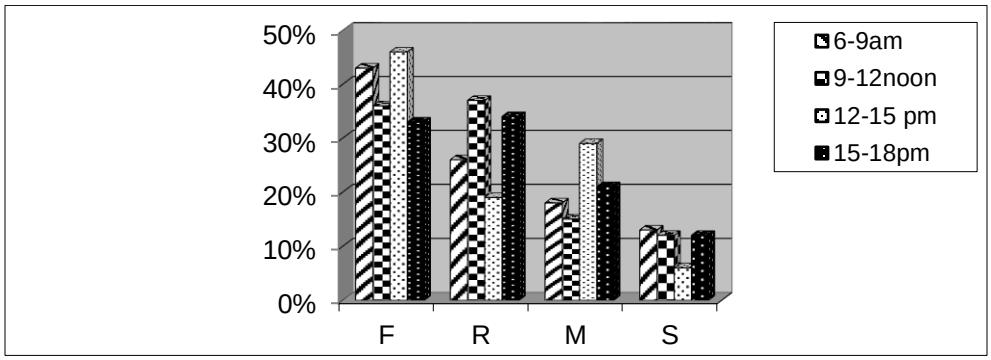

Figure 6: Major activities (F- Feeding and Foraging, R-Resting, M- Moving, S- Social) of Assamese macaque in time percentage according to four periods of time of a day in Nagarjun forest of SNNP in 2012.

4.2.2 Seasonal Change in behavior

As the data were collected in two seasons of the study year i.e. rainy and autumn so time spent on different four categories of behavior by the macaque in two seasons were tested by using χ^2 and it was found that time spent by the macaque in different four activities during two seasons was significantly different (χ^2= 20.59, df= 3, p <0.001). Time spent in social behavior was 14.35% in autumn where as in rainy season it was 6.70% but time spent in resting and moving behavior was more in rainy season than in autumn.

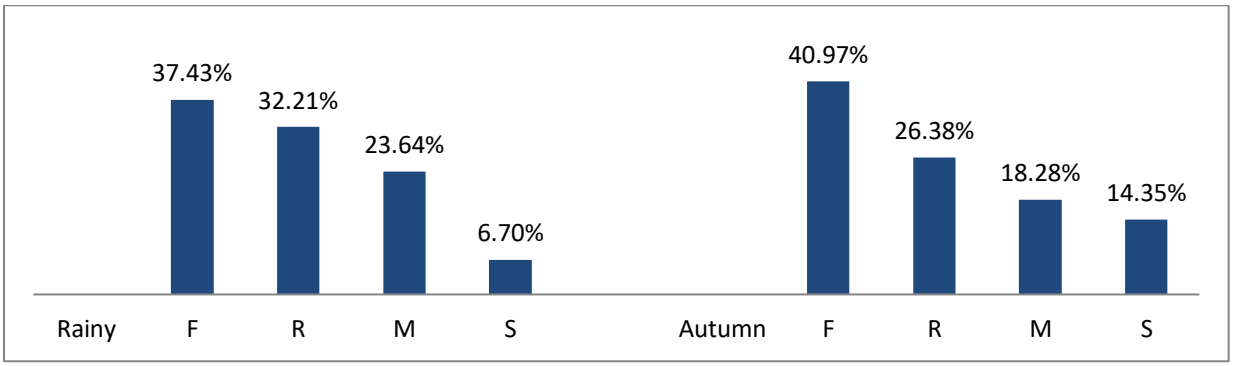

Figure 7: Percentage of time spent by Assamese macaque in four major activities (F- Feeding and Foraging, R-Resting, M- Moving, S- Social) in Rainy and Autumn Season in Nagarjun forest of SNNP in 2012.

4.2.3 Behavioral difference between two troops

Two troops of macaque were selected for the behavior study because of their difference in feeding habit i.e. Troop 'A' and Troop 'B'. It was found that time spent in different categories of behavior by the two troops of macaque were significantly different (χ^2=23.12, df=3, p<0.001). Troop 'B' spent more time in feeding and moving behavior and less time in social behavior than Troop 'A'.

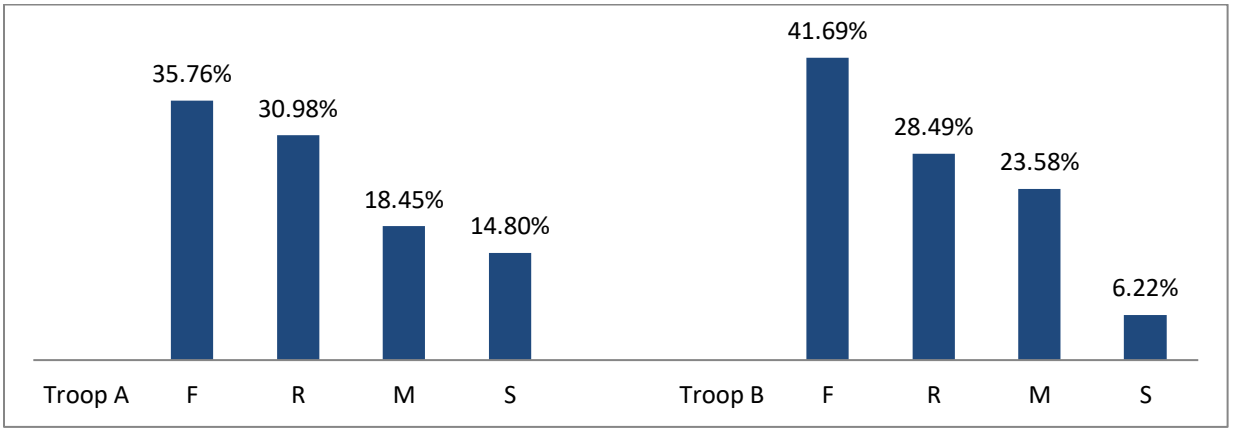

Figure 8: Percentage of time spent in different four categories of behavior (F- Feeding and Foraging, R-Resting, M- Moving, S- Social) by two troops of macaque in Nagarjun forest of SNNP in 2012.

4.2.4 Some behavioral records from Ad-libitum sampling

Some interesting behavior of the macaque related to learning behavior were recorded through Ad-libitum sampling; looking the mirror, wearing cap, inspecting any new type of bird (White Throated Kingfisher) encountered. Some reproductive behavior like male eating sperms, female eating vaginal plague after copulation; male sometime searching for vaginal plague of a female by raising tail, and the true copulation between adult male and female were followed by grooming for long period etc. were recorded in autumn season. Adult male grooming to infants, hugging and carrying them was also recorded throughout the study.

Troop 'A' always used rocky cliff as night settlement site, the rocky cliff were near the Army Camp Area so that troop A had good night settlement site and food source in the area. They reach their night settlement following sun set and spent some time in grooming activity, generally female carrying infant moves to the resting site at first.

Macaques spent their most of the diurnal time in middle canopy, they come on the floor for feeding purpose only and when they feel secured in the rocky cliff they rest and play on the floor.

Behavior of the macaque inside the forest was also influenced by stray dogs, visitors, rock climbers, illegally entered local peoples (to collect fodder and other resources) and security personals. Visitor throwing stones and teasing, stray dogs chasing the macaque were recorded. However, in general adult male defense with the dogs and adult females moved away carrying their infants.

Inside the Army Camp Area, giving biscuits and vegetable items to the macaques, sometime chasing them by loud voice influenced their behavior. Some aggressive behavior between the macaque and dogs were too recorded during feeding inside Camp Area. Generally macaques moved to upper canopy when dog come near to them and sometimes macaques too chased the dogs. Besides occurrence of Rhesus macaque inside the camp area has caused competition for food between the two macaque species resulting influence in behavior of Assamese macaque.

4.3 Feeding ecology

4.3.1. Food items

Among two troops of macaque Troop 'A' feeds on waste food from Army Canteen area. The waste food account 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 myas*) 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. There was significant difference in diet composition between the two study troops of macaque (χ^2= 98.60, df= 3, p< 0.001).

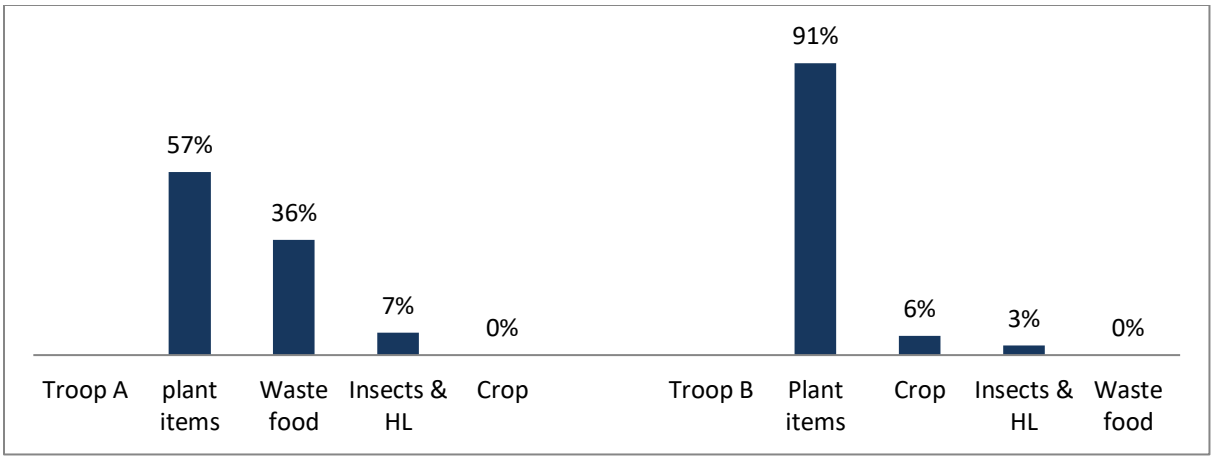

Figure 9: Basic food type and their percentage recorded in Troop 'A' and 'B' of Assamese macaque in Nagarjun forest of SNNP in 2012.

4.3.2. Plants diet composition

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.

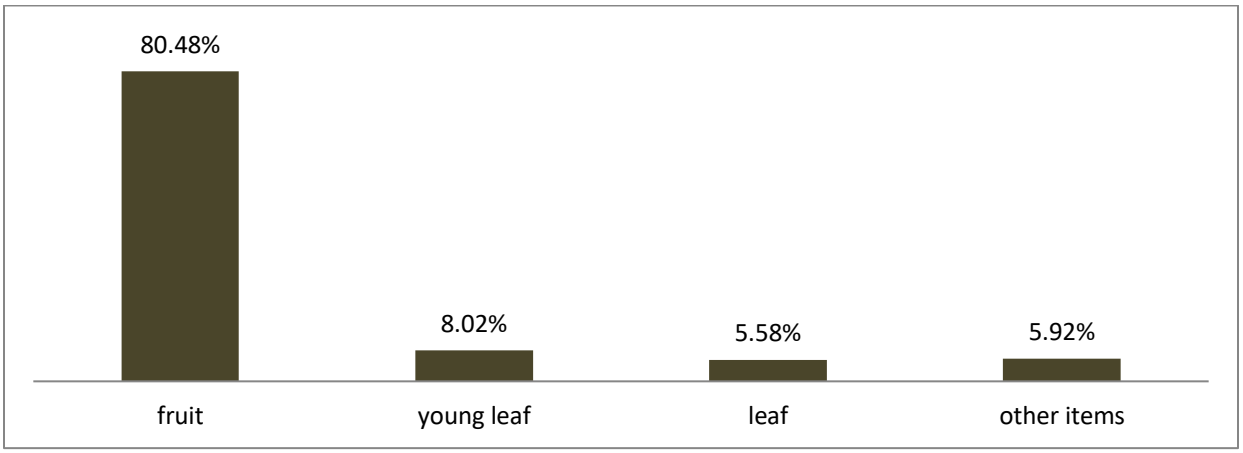

Figure 10: Plant diet composition and their percentage eaten by Assamese macaque in Nagarjun forest of SNNP in 2012.

4.3.3 Seasonal Changes in food items

There was significant difference between food items eaten by Troop 'A' (χ^2=42.46, df=9, p<0.001) and Troop 'B' (χ^2=24.67, df=7, p<0.001) in two different seasons i.e. Rainy and Autumn of the study year. In rainy season both the troops were recorded feeding on many food items including fruit, leaf,mushroom, insects and honeylick, bud, shoot, twig and tuber etc but in autumn only fruit and young leaf were recorded as food items except waste food for troop 'A'.

4.3.4. Food Plant Species

Macaques were observed to forage on 37 plant species which include 22 families (excluding families of unidentified six species), 28 species of tree, four species of vine, three species of shrubs and two species of herbs (ANNEX III and IV) during scan sampling and Ad-libitum sampling. Plant feeding records during scan sampling of both troops i.e. 'A' and 'B' of both season was complied 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 % (ANNEX III).

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 2: Appendix III). 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.

4.4 Vegetation related to macaques' feeding

In total 24 species of food trees were recorded from the macaque's habitat, 16 (52%) food tree species were recorded out of total 31 tree species from Fulbari where as 18 (45%) food tree species were recorded out of total 40 tree species from Simpani.

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) (Appendix V and VI).

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 disribution. *Schima wallichii* is randomly distributed in both sites (Appendix V and VI).

Species Richness and Shannon Weaver Diversity Index for total tree species was 31 and 1.16 and 40 and 1.26 respectively for Fulbari and Simpani. And for food species, Species Richness and Shannon Weaver Diversity Index was 16 and 0.699 and 18 and 0.82 respectively for Fulbari and Simpani respectively (Appendix V and VI).

5. DISCUSSION

5.1 Population

Five troops with total number of 137 individuals of Assamese macaque were found at five different sites inside the Nagarjun forest of SNNP, however, Chalise et al. (2013) had recorded three troops of Assamese macaque having total 83 individuals in Nagarjun forest of SNNP; Troop size recorded was 35 from Fulbari, 32 from Simpani area and 17 from Sanagaun-Mudkhu. In this study number of recorded macaques was 43, 38 and 18 from Fulbari, Simpani and Andheri khola respectively. Chalise et al. (2013) collected the data during December 2011-March 2012 in Nagarjun but for this study population survey was conducted on April 2013. April - June is the time of reproduction of the Assamese macaque (Fartbauer 2010) so may be due to the seasonal variation on time of survey more macaques were recorded during this study compared to Chalise et al. (2013). Additionally, two troops were recorded from Yendada and Raniban during this study. Yendada was recorded as potential site for Assamese macaque by Chalise et al. (2013). Previously, in 1985 Wada (2005) had recorded Assamese macaque in Nagarjun forest for the first time and the total individual counted was 98.

The group density of Assamese macaque in this study was found 0.31groups/km^2 and population density was found 8.56 individuals/km^2. Whereas Regmi (2008) found the group density of the macaque 0.0790 groups/Km^2 with a population density of 1.8691 individuals/ km^2 in LNP. Similarly, from Lower Kanchanjungha Area the estimated group density and population density were 1.2253 groups/km^2 and 32.733 respectively for Assamese macaque (Regmi and Kandel 2013). Absence of corridor to connect next forest patch (SNNP 2011) and easily available food resource might be the reason for high rate of population density of the macaque in the study area.

The mean troop size of Assamese macaque in Nagarjun was found 27.4 (Range 17-43) individuals which lies within the range of Assamese macaque recorded in LNP that was 23.66 (Range 13-35) from nine groups of macaque (Regmi 2008) and near to the mean troop size in Lower Kanchanjungha Area in Eastern Nepal in which estimated group size was 26.714 (Regmi and Kandel 2013). But the mean troop size is more than the size estimated by Wada (2005) with range 5-34 (mean 19.1).

There is slightly less adult male population than adult female (sex ratio 0.73) and the ratio is near to Chalise et al. (2013) i.e. 0.97. But according to Chalise (2003) adult sex ration was 1:1.6 in MBNP in 1997. Each female has 0.84 infants during the study which is more than Chalise et al. (2013); according to them each female has 0.67 infants. There were 22.45% infants, 18.37% juvenile, 13.26% young, 19.39% adult male and 26.53% adult females in study area (Table 1). Regmi (2008) found 19% infant, 16% juvenile, 18% young, 16% adult male and 31% adult female among the total macaque population counted in LNP.

5.2 General Behavior

Behavior is the response of both the physical as well as habitat condition of the animal. It varies from habitat to habitat depending upon the resource distribution. In primates, food, mates, drink and roosting trees are the most important resource, which controls activity (Sarkar 2000). Among these resources, food seems to be the most crucial primary factor which regulates day-to-day activity profiles (Sarkar et al. 2012).

General behavior of primate is generally categorized in five classes of category i.e. Feeding, foraging, resting, moving and social (which includes allogrooming, playing, sexual behavior, vocalizations 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). In this study too behaviors are categorized in four classes i.e. feeding, moving, resting and social.

Recorded pattern of time spent by Assamese macaque of Nagarjun forest in major behavioral categories is in accordance with other studies of Assamese macaque in Nepal i.e. they spent more time in feeding activity than other activities (Chalise 2003, 2010). Assamese macaque spent greater percentage of time in foraging and feeding activities; it is 43.4% in LNP (Chalise 2010) and 44% in MBCA (Chalise 2003); which is greater than this study i.e. 37.86%. On the other hand the macaques spent 30.06% of time in resting followed by 21.88% in moving and 10.18% in social activities in this study which differs than the previous studies of macaque in

Nepal (Chalise 2003; 2010). Chalise (2010) had recorded 18.5% in resting, 31.7% in moving and 3.4% of time in grooming behavior in LNP. Similarly, Chalise (2003) has recorded 18% in resting, 25% in moving and 13% in Grooming in MBCA. A study in Assam too reports that Assamese macaque spent more than one third (40%) of their total time for foraging and feeding purpose followed by 25% on locomotion, and 13% on resting (Sarkar et al. 2012).

Feeding is the most crucial factor responsible for the variation in the time spent in different behavior (Sarkar et al. 2012). In case of this study one of the troops i.e. Troop 'A' feeds on waste food from Army Camp, they don't have to forage for food in large area as the waste food is easily available. May be, due to this reason they could get greater percentage of time for resting as compared to the previous studies (chalise 2003, 2010). Besides this, it is found that Troop 'A' spent only 35.76% of time in foraging and feeding activities but Troop 'B' spent 41.69% of time for feeding purpose; similarly Troop 'B' spent 23.58% of time in moving but Troop 'A' spent only 18.45% of their total time in moving. In case of resting and social activities Troop 'A' spent more time than Troop 'B'; Troop 'B' spent only 6.23% of time in social activities but Troop 'A' spent about 15% of their time in social activities. For Troop 'A' food was easily available compared to Troop 'B', so they have to spend less time in locomotion and foraging and feeding activities than Troop 'B'. But Troop 'B' spent more time on feeding, and locomotion; so, the time remains for resting and social activities are less than Troop 'A'. High locomotion and foraging activity cost more energy expenditure and therefore, the group re-allocates the time budgeting for higher resting activity, and allocates a less time for social activities like grooming and play activities (Sarkar et al. 2012).

Some reproductive behavior like male eating sperms, female eating vaginal plague after copulation; male sometime searching for vaginal plague of female by raising tail, and the true copulation between adult male and female were followed by grooming for long period etc were recorded in autumn season as reported by Chalise (2003) and Chalise et al. (2013).

Sleeping sites of Assamese macaque were typically rocky cliffs in MBCA and LNP, they provide some security against carnivores (Chalise 2003); this study also supports this fact. Troop 'A' always used rocky cliff as night settlement site, the rocky cliff were near the Army Camp

Area so that troop 'A' had good night settlement site and food source in the area. Beside Troop 'A' macaque's troop recorded from Raniban used rocky cliff for night settlement.

5.3 Feeding ecology

Macaque species have been described primarily frugivorous, for example O'Brien and Kinnaird (1997) reported that Crested black macaques *Macaca nigra* spent 66% of feeding time on fruit; a study of Tonkean macaque *M. tonkeana* in Sulawesi, Indonesia, showed that fruits accounted for 76.7%-84.4% of their diets (Riley 2007). However, evidence is steadily accumulating that leaves contribute a large proportion of diet in some species (Zhao 1996, Hanya 2004). For example, Japanese macaques *M. fuscata* in the coniferous forest of Yakushima spent 45% of feeding time on leaves, and feeding time on fruits was only 13% (Hanya 2004). 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). For example, Hanya et al. (2003) found variation in diet amongst Japanese macaques inhabiting different altitudinal zones. 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).

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). 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% & 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.

Food items eaten by both troops were significantly different in rainy and autumn seasons. For Troop 'A', 10 different food items including waste food, insects and honey, different plant parts like fruit, leaf, tuber, twig, shoot, young leaf, flower etc. were recorded in rainy season but in case of autumn only three food items i.e. fruit, young leaf and waste food was recorded; and same condition was found in case of Troop 'B'. 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 (Chalise 2000); this may be the reason behind recording few food items in autumn compared to rainy season. Besides data collection was done for more days in rainy season than in autumn.

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 (APPENDIX III). 14 food plants were recorded by Ad-libitum sampling which were not recorded during scan sampling (APPENDIX IV). 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).

5.4 Vegetation related to macaques' feeding

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).

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. 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 increasement of food plant number; in this case too this might be the reason for foraging on lower tree percentage by Troop 'B'.

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 (Appendix V and VI). 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 food resources.

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 trees were 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.

In case of present study only in Simpani 78% of food plants have patchy distribution and 22% of food plants have random distribution where as in Fulbari 81% of plants have patchily distribution and 19% of food plants have random distribution (Appendix V and VI). Among the 22% of randomly distributed food plants in Simpani *Syzygium cumini* and *Schima wallichii* accounted for > 3% of total feeding records but in case of Fulbari *Schima wallichii* is only present as food plant which accounts for > 3% of total feeding records. Time spent in different activities i.e. feeding, resting, moving and social is 35.76%, 30.98%, 18.45% and 14.80% and 41.69%, 28.49%, 23.58% and 6.22% for troop 'A' and 'B' respectively (Figure 8). Time spent in feeding and locomotion is comparatively greater in Troop 'B' than Troop 'A', but percentage of time spent in social behavior and resting is more in case of Troop 'A'. As more food plants have random distribution in Simpani than in Fulbari; greater the percentage of time spent in feeding and locomotion by Troop 'B'. High locomotion and foraging and feeding activity cost more energy expenditure by Troop 'B' and therefore, the group spent higher resting activity and gives less time for social activities than Troop 'A' (Sarkar et al. 2012). Inter-individual distances are more when the food is randomly distributed which reduces the time spent in social behavior (Sarkar et al. 2012).

6. CONCLUSION AND RECOMMENDATIONS

This study presents the current population status of Assamese macaque, their behavioral ecology, feeding ecology and vegetation of their habitat in relation to feeding and other behavior in Nagarjun forest of SNNP. It was supporting five troops of Assamese macaque and the results show that Nagarjun is prime habitat for Assamese macaque.

Among four major activities macaque spent greater percentage of time in foraging and feeding behavior followed by resting, moving and social. Unlike previous studies they spent greater percentage of time in resting behavior than in moving behavior which is due to the availability of waste food and may be due to the patchily distributed food resources.

Assamese macaques of Nagarjun 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. Food items eaten by the two troops of macaque were significantly different because food item selection is dependent on the availability of food source. They are highly frugivorous unlike other previous study of macaque. This study only includes the data of two seasons so further researches should be conducted to know dietary composition for whole year.

Tree Species having highest IVI are food plants of macaque in Nagarjun forest which shows that Nagarjun 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 different categories of behavior by macaque.

On the basis of this study some recommendation are put forward here for the effective management of the nationally protected macaque species in Nagarjun forest:

1. Further researches should be conducted to explore the diet composition, seasonal variation and utilization of vegetation throughout a year.
2. Visitors, rock climbers and security personals should be aware not to disturb the macaques. Stray dogs should be restricted to enter inside the park area.
3. Illegal entry of local people inside the park for collection of fodder and other resources should be controlled.

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PHOTOPLATE

Photo 1: Adult male resting

Photo 2: A Female having subcaudal sexual swelling.

Photo 3: Adult female feeding on Waste Food in Army Canteen area.

Photo 4: Collecting data following scan sampling.

APPENDICES

Appendix I: Data sheet used to count Population.

Population Count

Sheet no: *Date:*

Place	**GPS Point**	**Time**	**Age- Sex composition of macaque***						***Remarks***
			MA	**FA**	**Y**	**J**	***I***	***Total***	

* MA: Male Adult, FA: Female adult, Y: Young, J: Juvenile and I: Infant

Appendix II: Data Sheet used for feeding and behavioral observations.

Feeding and Behavioral Observations

Sheet no: Troop: A/B Date: Weather:

Scan Time: to Place: GPS Point:

Time	**Behavior**	**Feeding Behavior**		**Remarks**
		Plant	**Item**	

APPENDIX III:

Table 2: Plant species consumed by Assamese macaque recorded during Scan Sampling in 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	*Machilus duthiei*	Jhangrikath	Tree	Fr	15.26
	Dodecadenia grandiflora	Panhele	Tree	Fr	1.14
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

APPENDIX IV:

Table 3: Food plants of Assamese macaque recorded during Ad-libitum 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

APPENDIX V:

Table 4: IVI, Shannon Weaver Index, Whitford's Index calculated for trees in Fulbari.

Scientific name	Local name	IVI	Shannon-Weaver Index	Whitford's Index	Disturbation Pattern
Food Trees					
Betula alnoides	Saur	9.08	0.027	0.02	Contagious
Castanopsis tribuloides	Musure katus	25.80	0.109	0.11	Contagious
Celtis Australia	Khari	13.91	0.050	0.06	Contagious
Choerospondias axilllaris	Lapsi	2.60	0.011	0.22	Contagious
Dodecadenia grandiflora	Panhele	8.03	0.045	0.08	Contagious
Ficus lacor	Kapro	1.54	0.011	0.22	Contagious
Ficus sarmentosa	Bedulo	1.48	0.011	0.22	Contagious
Ficus semicordata	Khania	2.55	0.011	0.22	Contagious
Grewia asiatica		3.01	0.019	0.11	Contagious
Machilus duthiei	Jhangrikath	47.43	0.122	0.07	Contagious
Schima wallichii	Chilaune	60.33	0.142	0.03	Random
Zizyphus incurve	Hadebayar	4.94	0.019	0.11	Contagious
	UNI 1	8.40	0.033	0.10	Contagious
	UNI 3	8.01	0.039	0.04	Random
	UNI 4	1.54	0.011	0.22	Contagious
	UNI 5*	7.75	0.039	0.04	Random
Total			**0.699**		
Other trees					
Acer oblongum	Phirephire	8.09	0.039	0.07	Contagious
Alnus nepalensis	Uttis	9.52	0.033	0.10	Contagious
Colquhounia coccinea	Sano tusare	1.56	0.011	0.22	Contagious
Engelhardia spicata	Mauwa	3.14	0.019	0.11	Contagious
Eurya acuminate	Jhigani	6.16	0.039	0.12	Contagious
Fraxinus floribunda	Lakuri	8.72	0.045	0.05	Contagious
Macaranga indica	Maledo	1.80	0.011	0.22	Contagious
Myrsine capitellata	Setikath	16.72	0.090	0.10	Contagious
Pinus wallichiana	Gobresalla	3.36	0.011	0.22	Contagious
Pyrus pashia	Mayal	1.49	0.011	0.22	Contagious
Quercus spp.	Phalat	22.62	0.096	0.07	Contagious
Stranvaesia nussia	Nasi	5.75	0.019	0.11	Contagious
	Baklepat	1.57	0.011	0.22	Contagious
	UNI 8	1.57	0.011	0.22	Contagious
	UNI 9	1.53	0.011	0.22	Contagious
Total			**0.463**		
Grand Total		**300.00**	**1.16**		

*UNI: Unidentified

APPENDIX VI:

Table 5: IVI, Shannon Weaver Index, Whitford's Index calculated for trees in Simpani.

Scientific name	Local name	IVI	Shannon-Weaver Index	Whitford's Index	Disturbation Pattern
Food Trees					
Betula alnoides	Saur	13.05	0.042	0.08	Contagious
Bombax ceiba	Simal	10.20	0.037	0.12	Contagious
Castanopsis tribuloides	Musurekatus	50.59	0.145	0.06	Contagious
Celtis Australia	Khari	1.76	0.010	0.22	Contagious
Choerospondias axilllaris	Lapsi	14.14	0.042	0.08	Contagious
Dodecadenia grandiflora	Panhele	23.52	0.094	0.04	Random
Grewia asiatica		2.04	0.018	0.44	Contagious
lindera nacusua	Panhelo khapate	1.36	0.010	0.22	Contagious
Machilus duthiei	Jhangrikath	13.89	0.068	0.17	Contagious
Myrrica esculenta	Kafal	9.30	0.056	0.12	Contagious
Prunus cerasoides	Payou	1.40	0.037	0.22	Contagious
Saurauia napaulensis	Gogan	1.42	0.010	0.22	Contagious
Schima wallichii	Chilaune	34.35	0.119	0.05	Random
Syzygium cumini	Jamun	9.77	0.052	0.05	Random
Zizyphus incurve	Hade bayar	6.25	0.031	0.06	Contagious
Zizyphus mauritiana	Bayar	1.45	0.010	0.22	Contagious
	UNI 1*	6.23	0.025	0.07	Contagious
	UNI 6	2.70	0.010	0.22	Contagious
Total			**0.82**		
Other Trees					
Acer oblongum	Phiphire	10.70	0.052	0.05	Random
Albizzia spp.	Siris	13.69	0.037	0.04	Random
Alnus nepalensis	Uttis	6.73	0.021	0.22	Contagious
Castanopsis indica	Dhale Katus	3.44	0.018	0.22	Contagious
Cinnamomum tama	Tejpatta	1.46	0.018	0.22	Contagious
Eriobotrya dubia	Jure kafal	2.06	0.010	0.22	Contagious
Eurya acuminate	Jhigani	1.37	0.010	0.22	Contagious
Fraxinus floribunda	Lakuri	1.46	0.010	0.22	Contagious
Hydrangea heteromalla	Fusretat	1.97	0.021	0.22	Contagious
Lyonia ovalifolia	Aangeri	3.01	0.025	0.11	Contagious
Machilus spp.	Musurekath	1.46	0.018	0.22	Contagious
Madhuca longifolia	Mauwa	1.49	0.010	0.22	Contagious
Myrsine capitellata	Setikath	4.20	0.025	0.07	Contagious
Persea odoratissima	Kaulo	2.63	0.025	0.44	Contagious
Pinus wallichiana	Gobre salla	5.87	0.025	0.66	Contagious
Quercus spp.	Phalat	19.21	0.076	0.09	Contagious
Stranvaesia nussia	Nasi	4.87	0.037	0.28	Contagious
Symplocos ramosissima	Dabdabe	1.47	0.010	0.22	Contagious
	Mirmire	2.86	0.010	0.44	Contagious
	Pipiri	3.69	0.018	0.17	Contagious
	UNI 7	1.38	0.025	0.22	Contagious
	UNI 9	1.56	0.018	0.22	Contagious
Total			**0.436**		
Grand Total		**300.00**	**1.263**		

*UNI: Unidentified