“Life in the extreme: Time-activity budgets and foraging ecology of Central Himalayan Langur (*Semnopithecus schistaceus)* in the Kedarnath Wildlife Sanctuary, Uttarakhand India”

A dissertation submitted to
A.V.C College (Autonomous), Mannampandal,
(Affiliated to the Bharathidasan University, Thiruchirapalli)
In partial fulfillment of the requirement for the Degree of

Master of Science in
WILDLIFE BIOLOGY

Submitted by
Ms. Himani Nautiyal
(Reg. No. P13 7727)

P.G. and Research Department of Zoology and Wildlife Biology
A.V.C. College (Autonomous),
(Reaccredited and Awarded “A” Grade status by NAAC
and “College with potential for Excellence”by UGC)
Mannampandal, Mayiladuthurai – 609 305

April 2015

J. PANDIYAN, Ph.D.,
stant Professor

Department of Zoology & Wildlife Biology
A.V.C. College (Autonomous)
Mannampandal - 609 305
Mayiladuturai - Tamilnadu, India

30/4/15

CERTIFICATE

This is to certify that this project work was done under our guidance and the dissertation entitled **"Life in the extreme: Time-activity budgets and foraging ecology of Central Himalayan Langur (*Semnopithecus schistaceus*) in the Kedarnath Wildlife Sanctuary, Uttarakhand India"** submitted by **MS. HIMANI NAUTIYAL** (Reg. No. P137727) in partial fulfilment of the requirement of the M.Sc., Degree in Wildlife Biology for the period of 2013-2015, is the original work of the candidate

Signature of the Co-Guide

Signature of the Guide

NATIONAL INSTITUTE OF ADVANCED STUDIES

30.4.2015

for **Signature of the Head of the Department**

Head of the Department of Zoology & Wildlife Biology, A.V.C.College (Autonomous), Mannampandal-609 305.

Examiners

1. (P.KRVIN ANJOUR ?)

2.

Off : 0091 - 04364 - 222264

ACKNOWLEDGEMENT

I would like to earnestly thank to my supervisor, **Dr. J. Pandiyan**., Asst. Prof. of Zoology & Wildlife without whom study would have been impossible.. Most importantly I thank him for his constant encouragement and support throughout the course.

I am grateful to my co supervisor **Prof. Anindya Sinha**, National Institute of Advance Study, Bangalore for guidance, valuable advice and above all for her patience with me right from the beginning of the project. His intellectual contribution not only strengthened my dissertation and graduate career, but has also made a lasting impression that will shape my approach to future research.

None of this would have ever been possible without the help, support and undying enthusiasm of **Dr. M. Varadhrajan,** Principal of A.V.C College.

I sincerely thank **Dr. S Asokan,** HOD Zoology and Wildlife Biology for his continuous help and support throughout the study.

I express my sincere thanks to all staff members for valuable inputs **Dr. M. Baskaran, Dr. N. Bhaskaran, Dr. J.V. Thenmozhi, Dr. M. Karthikeyan**, and other staff of Department of Zoology & Wildlife Biology.

I thank **Dr. Akash Verma** DFO, Kedarnath Wildlife Santuary for granting the required permits, providing valuable information and arranging for logistic support, but most of all I am indebted to him for his generosity and constant encouragement.

It is very hard to say my obligations in words to **Prof. Michael A. Huffman** Kyoto University, Primate Research Institute Japan, his guidance and encouragement helped me a lot to take many decision throughout my working period even after that.

I am grateful to my field assistants **Abhi** and **Priya** , I would never have been able to complete this study without their brilliant field skills and good company.

I am forever indebted to the people of **Siroli** and **Sanso Village** for accepting me as one of their own, for the love and kindness they showered on me.

I thank **Asmita** and **Priya,** for fruitful discussions and valuable inputs and I also thank to **Manisha** helping me with plant species identification.

I sincerely thank my classmates, **Alissa, Janice** and **Dev** for their suggestion to my study and also thank to **Sahas, Viral, Soham, Shaili, Harish ji ,Khushi, Susmita, Esmita** for good company in the field.

My deep gratitude to my **mother Rani Nautiyal** taught me how to care for people, how to overcome obstacles, how to be independent and capable. She always supported me in all of my academic endeavours. I owe all of my professional success to her. I thank to my **father OM Prakash Nautiyal** supporting me always and believing on me.

I thank **Ruffod Small Grant, UK., for funding** the study, **A.V.C College** for academic support and **Bharathidasan University, Trichy** for certifying the course.

It is obvious to say that the absence of the persons who have helped me in any way, in my thanks just for an acute lack of space and memory rather than lack of gratitude; I am apologizing if anyone has been left out.

Finally I thank to the study animal “Central Himalayan Langur” *Semnopithecus schistaceus* for their patience and acceptance throughout the study.

Himani Nautiyal

CONTENTS

I. INTRODUCTION

1.1. Introduction

The Hanuman Langur is one of the most widely distributed primates in the Indian subcontinent inhabiting a variety of habitats, ranging from desert to rainforest and from sea level up to 4000 m, in the Himalayas (Kumar, 1987). Researchers have studied the lowland Central Himalayan Langur extensively; but there is little information about the Himalayan population and their taxonomy (Bishop, 1975., 1979). The Himalayan region is one of the world's sensitive hotspot to climate change. Being located near the mountain tops, alpine species are highly vulnerable to global warming (Benniston, 2003). There would be drastic changes in the life history of several animals living in alpine and temperate areas and this problem would be faced by the primate species too. While considering the recent climatic changes, the species in alpine ecosystem might be faced with very different conditions including different competitors, predators and food base (Singh, 2007). The study of its ecology and behaviour and its interaction with humans will enable us to understand the problems encountered by these species in alpine and temperate regions. Interspecific and intraspecific variation in activities of nonhuman primates offers important information about evolution of society and life history pattern in primates (Masi et. al., 2009). Primates living in temperate or alpine ecozones provide excellent opportunities for documenting the limits of phenotypic plasticity of our order (Sayers & Norcock, 2008).

The present study describes the activity patterns of a wild troop of Central Himalayan Langur on the Garhwal Himalayas. Central Himalayan Langur ecology and behaviour is different from the lowland langurs. High land langurs form multi female and multi male dominated society with expanded home ranges which is different from the lowland langurs (Bishop, 1979).The aim of this study is to provide the first detailed account of activity performed by two langurs troops in natural forest and an anthropogenic farmland located at the forest periphery. I also examine what are the factors responsible for the activity budget. These two langur troops live in a different environment where the availability of food resources varies. Primates survival and reproduction is effect of time distribution among all activities (Watts, 1988). Forest Troop Spent more time on resting and moving and less on social interactions compared to the Village Troop. Low quality diets may require an increase in the time spent feeding and moving which may affect time spend in other activities such as resting and sociality (Bronnikowski & Altmann, 1996).

Data on activity patterns are central to testing hypotheses about ecological influences on social behaviour and group living. Activity budgets have been included as part of basic natural history for many group-living primate species, (Terborgh, 1983; Stanford, 1991). Most studies of activity budgets have shown that the time spent in different activities can vary both diurnally and seasonally within groups. Time budgets are influenced by group size, habitat quality (Dunbar, 1992) and proximity to human settlements (Singh & Vinathe 1990).

Understanding of the survival of a given taxon in a habitat and identifying the areas suitable for the species determine by studying activity pattern (Dunbar et. al., 2009). In many primate groups, activity patterns may be affected by climatic variables and habitat characteristics (Dunbar, 1988, Dunbar et .al., 2009). The importance of temperature in primate behavioural ecology has received relatively little attention in comparison to other ecological factors (Stelzner, 1988). One important aspect of a species' ecology is the proportion of time that the animals spend in different activities and the distribution of these activities throughout the day. (Cluttion-Brock, 1977) conducted inter-species comparisons in the feeding and ranging behaviour of primates, examining the correlations between many environmental variables. Time budgets indicate how individuals in a species interact with its environment and they show the investment in time that is necessary for activities that are important for the species survival and reproduction (Defler, 1995).

To improve understanding of the socio-ecological strategies of alpine grey langurs and to elucidate how these primates have managed to settle in resource-poor and climatologically demanding high-altitude environments, we examined the effects of both ecological and social factors on the feeding of two groups of different sizes and compositions of the Central Himalayan langur in Kedarnath Wildlife Sanctuary. I present preliminary data on the diet and feeding ecology of the Central Himalan Langur in the Garhwal Himalayas. I examine patterns of dietary richness and food selection and related them to a concurrent study of the composition and phenology off the plant community at the site.

Crop-raiding by primates is increasingly known to cause conflict between humans and primates, and due to their opportunism, adaptability, intelligence and manipulative abilities, primates can be significant agricultural pests. Crop-raiding is a form of human-wildlife conflict which directly affects local people's perception of and support for conservation initiatives. The effective long term conservation of wildlife in and around protected areas requires the support of the people who experience the direct impact of establishment and management of these areas (Kiss, 1992, Western & Wnght 1994).

The foraging strategy of an animal influences virtually every facet of its existence, and it is therefore not surprising that contrasts have frequently been made between primate folivores and those with other dietetic categorizations, such as frugivores, insectivores, and gumnivores. Years ago, it was common for primate ecologists to provide explicit generalizations about folivore behavior or evolution influenced by the common premise that ''the world is green'' (Stephens and Krebs, 1986)

Nutritional ecology of primates deals with how wild primates satisfy their dietary needs by procuring, digesting and metabolising the right kinds of food (Mcwilliams and Island, 2002). Diet selection is a challenging task for folivorous primates in temperate forests because the leaves, from which they have to obtain energy, protein and other nutrients, are also often laden with toxic secondary metabolites. Studies till now have examined the selection of individual species as a function of their nutritional value (energy and protein) and harmful secondary metabolites.

1.2. Goals and objectives of the thesis

Detailed observations of Central Himalayan langur foraging behaviour have yet to be collected. For example, no studies have included systematic quantification of diet coupled with phenological sampling. There have also been no studies that have attempted to identify Himalayan langur food preference or quantify the relationships between resource abundance, activity patterns, diet. The current study is an attempt to remedy the situation, investigating Himalayan langur foraging ecology and activity pattern in temperate region of the Garhwal Himalayas

Objectives

1) Quantify Central Himalayan Langur activity patterns and activity budget in two different habitats.
    a. Time- activity budget difference between adult male and adult female.
    b. Time- activity budget difference between adult and immature.
    c. Time- activity budget and time activity pattern difference between two habitats.

2) Quantify influence of environmental parameters on activity pattern of Central Himalayan Langur in two different habitats
    a. Effect of ambient temperature.
    b. Effect of relative humidity.
    c. Effect of light intensity

3) Quantify Central Himalayan Langur diet and resource availability in two different habitats.
4) Identify food species and food part preference for two study troops

    a. Food part preference: comparing plant part consumption and abundance based on phenology scores.
    b. Food species preference: comparing percent time feeding and availability of food species.

II. STUDY AREA

2.1. Location

Study carried out in Kedarnath Wildlife Sanctuary (KWLS), Uttrakhand India. KWLS is the largest protected area in the Himalayas (975 km^2). KWLS (30^{0}25' to 30^{0}45' N and 78^0 55' to 79^0 22' E) is located in Chmoli district, Garhwal region. My study were conducted in two regions of the Sanctuary, namely Mandal village -N 30 28.74’, E 79 16.942’ (1558 - 2000m) and Trishula Reserve Forest of Kedarnath Forest Division (Figure 2.1) N 30 28.011’, E79 15.629’, (1900-2500m). Kedarnath Wildlife Sanctuary (KWLS) was established in 1972 and is famous for the endangered Musk Deer. (Figure 2.2)

2.2. Climate

Mean annual maximum temperature was recorded as 16.41 ± 3.60 °C, whereas mean annual minimum temperature as 6.14 ± 1.98 °C. Mean annual rainfall was recorded as 2044.47 ± 476.01 mm. Mean Relative humidity round the year ranged from 15 % to 86 %. The rainy season accounts for about three-quarters of the annual rainfall. At the study site, the year is represented by three main seasons; the cool and relatively dry winter (December to March); the warm and dry summer (mid-April to June); and a warm and wet period (July to mid September) called as the monsoon or rainy season. Apart from these main seasons, the transitional periods interconnecting rainy and winter, and winter and summer referred to as autumn (October to November) and spring (February to March) are also observed (Gairola et. al., 2010).

2.3 Flora

It is a rich moist temperate forest; (Gairola et al., 2010) have recorded 338 species of vascular plants (334 angiosperms and 4 gymnosperms) belonging to 93 families (91 angiosperms and 2 gymnosperms) and 249 genera (246 angiosperms and 3 gymnosperms) from the study area. It is characterized by undulating topography with gentle slopes on the north, northeast and northwest faces and somewhat steep slopes in the south and southwest directions. There are nineteen types of vegetation in the KWLS based on (Champion & Seth, 1998) classification. It is estimated that about 44.4% to 48.8% of the sanctuary is forested, 7.7% comprises alpine meadows and scrub, 42.1% is rocky or under permanent snow and 1.5% represents formerly forested areas (Prabhakar et. al., 2001). A total of 530 species of dicotyledons and 691 species of monocotyledons have been recorded from KWLS (Kala and Gaur, 1982). The major forest types are:

1: Subtropical zone – Pine and Oak (upto 2000 msl)
2: Temperate Oak- fir and Maple (2,500–2,800 msl)
3: Subalpine Oak-Fir-Maple (2,850–3,150 msl)
4: Krumholtz' or Rhododendron stands (3,100–3,300 msl)
5: Sub-alpine fir (2,850–3,150 msl)
6: Subalpine scattered tree and scrub (2,800–3,200 msl)
7: Alpine meadows and rocks (>3,200 msl)

2.4 Fauna

23 mammalian species are recorded in the in the sanctuary out of which 11 are threatened. The primates are Rhesus macaque (*Macaca mulatta)* and Central Himalayayan (*Presbytis schistaceus).* Carnivores include Jackal (*Canis aureus)*, Fox (*Vulpes vulpes)*, Black Bear (*Selenarctos thibetanus)*, Yellow-throated Marten (*Martes flavigula)*, Leopard Cat (*Felis bengalensis)*, Common Leopard (*Panthera pardus)* and Snow Leopard (*Panthera uncia)*. Ungulates are Wild Boar (*Sus scrofa)*, Musk Deer (*Moschus chrysogaster)*, Indian Muntjac (*Muntiacus muntjak)*, Sambar (*Cervus unicolor)*, Goral (*Nemorhaedus goral)*, Serow (*Capricornis sumatraensis)*, Himalayan Tahr (*Hemitragus jemlahicus)* and Bharal (*Pseudois nayaur)*. Over 230 species of birds are reported from the area. Himalayan Monal Pheasant (*Lophophorus impejanu)*, Kalij Pheasant (*Lophura leucomelana)* and Koklass Pheasant (*Pucrasia macrolopha*) are common in occurrence.

2.5. Soil and Rock type

The soil types are brown and black forest soils and podzolic soils. Soil texture is predominantly sandy loam and sandy clay loam, whereas soil color varies from yellowish brown to dark brown (Sharma et. al., 2009b).

Geologically, the rocks are complex mixtures of mainly sedimentary, low-grade metamorphosed materials. The study area lies in the central axis of the great Himalayas, which consists of belts of metamorphic rocks (i.e., gneisses, granites and schists), known as the Central Crystalline group. Most of the rocks in the study area are fine to coarse-grained schists, all very much interleaved.

Figure 2.1. Map showing Trishula Block in the Kedarnath Wildlife Sanctuary with two different study site.

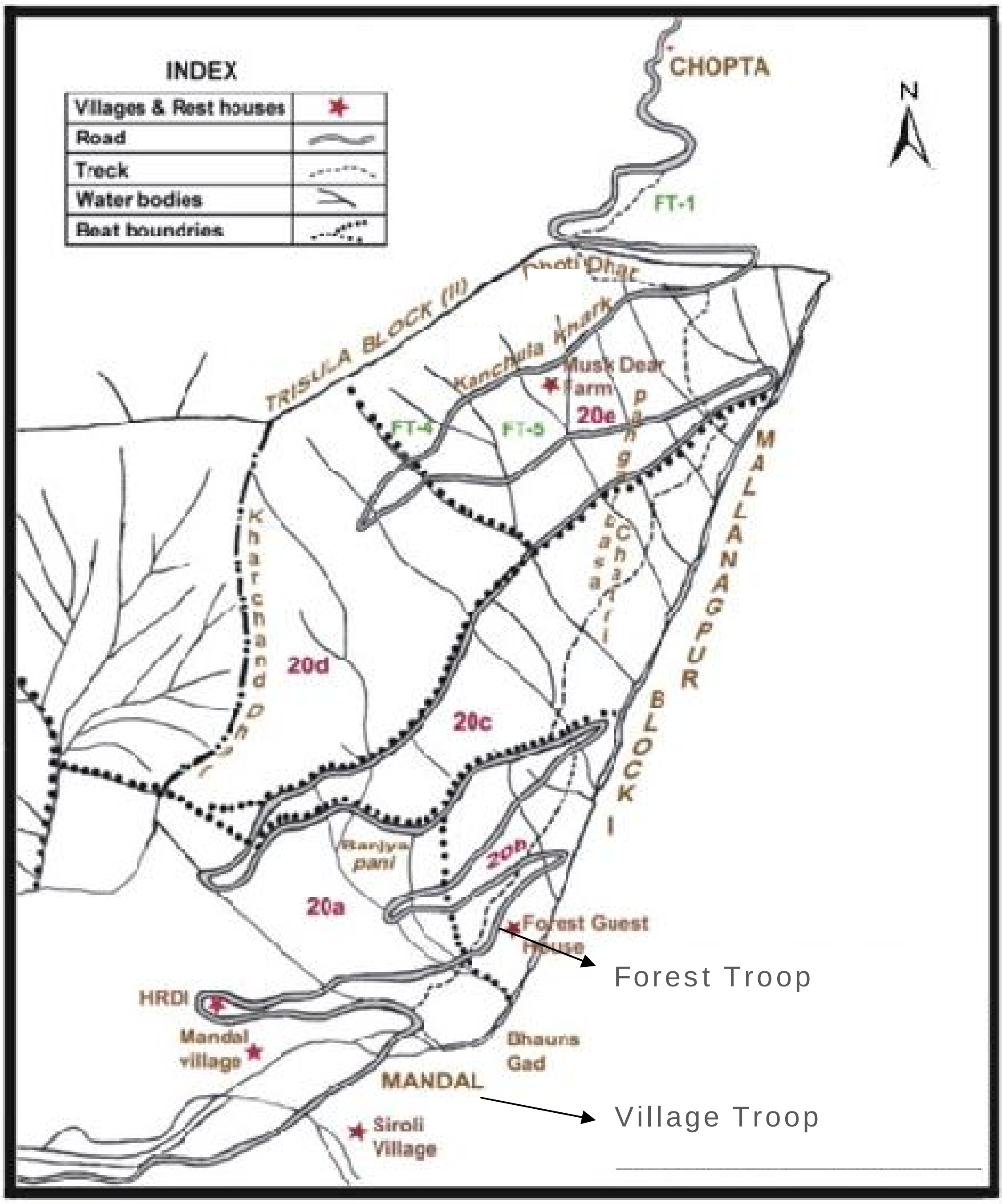
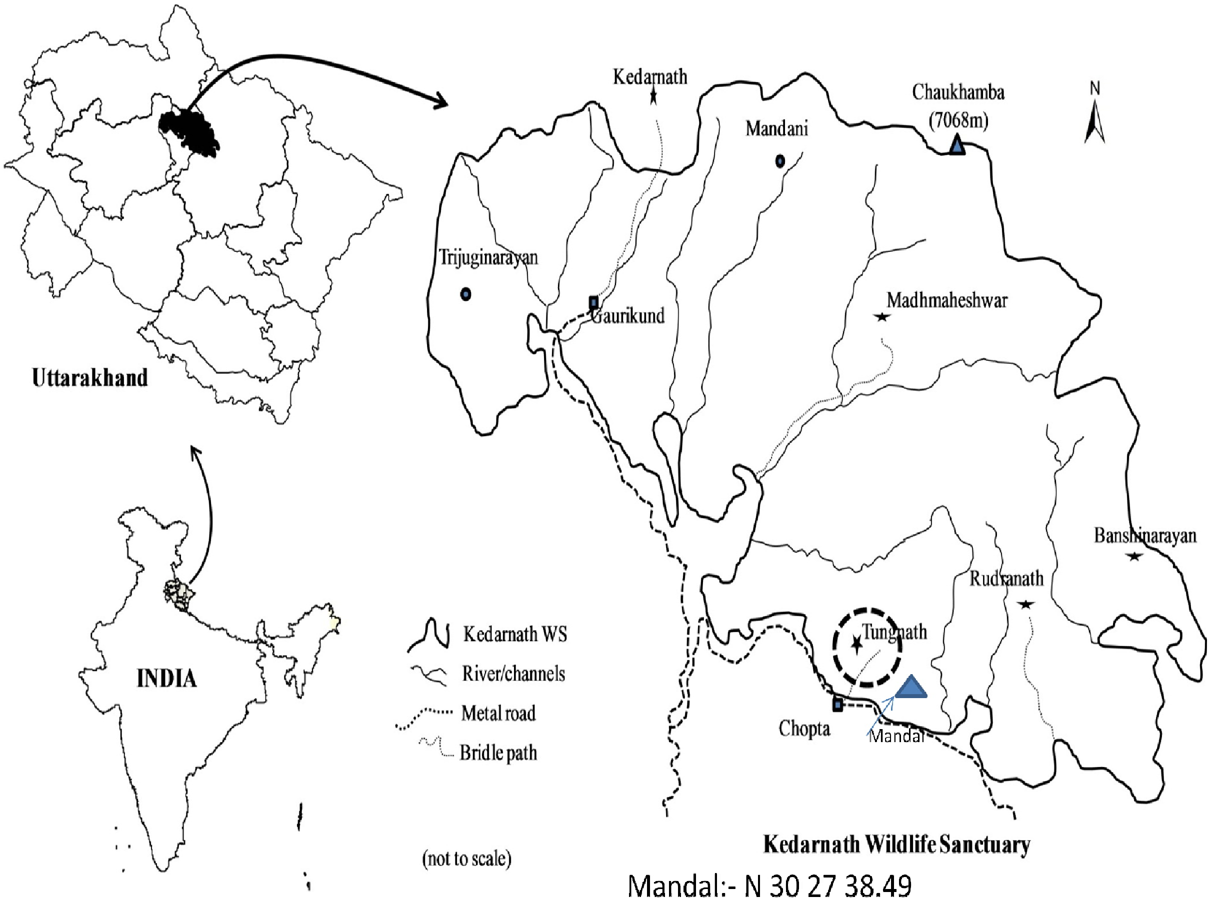


Figure 2.2. Map of Uttarakhand showing Kedarnath Wildlife Sanctuary



Mandal:- N 30 27 38.49
E 79 16 28.78

III. STUDY SPECIES

I chose one troop in the main Mandal Valley, this troop spend most of the time near by the human settlements (Village Troop). After 1 months of habituation, Village Troop could generally be approached to within 5 m, but observations in all months were limited more by weather and habitat characteristics than by habituation. Group size for Village Troop ranged from 48- individuals (Table 3.1). Secondary habituated, Forest Troop travelled only inside the forest. Highest count for Forest Troop included 63 individuals.

Table 3.1: Age/Sex ratio of Village and Forest Troop of Central Himalayan Langur

S.N	Age/sex	Forest Troop	Village Troop	Total
1	Adult male	6	5	11
2	Adult female	14	12	26
3	Subadult	18	7	25
4	Juvenile	12	8	20
5	Infant	8	12	20
6	New born	5	4	9
	Total	**63**	**48**	**111**

3.1. Taxonomic identification of study subjects

Langurs belong to a large group of Old World monkeys called the colobines (family Cercopithecidae subfamily Colobinae) and are distributed in tropical Asia. The colobines are unique among primates in that they are predominantly leaf eaters and exhibit foregut fermentation (Chivers and Hladik 1980). It is generally agreed that the colobines consist of two groups, or clades—the African colobus monkeys and the Asian langur and leaf monkeys

(Oates et, al., 1994., Disotell, 2000). Asian colobines have been divided into five or six species groups depending on the author (Napier & Napier 1965., Oates et. al., 1994., Groves, 2001., Brandon-Jones et, al., 2004). According to the most recent classifications (Groves 2001; Brandon-Jones et al. 2004), the Asian colobines consist of five species groups. These include langurs (*Semnopithecus*), leaf monkeys (*Trachypithecus*), surili (*Presbytis*), snub-nosed monkeys (*Rhinopithecus* and *Pygathrix*), proboscis monkey (*Nasalis*), and pig-tailed monkey (*Simias*). In South Asia, colobines are represented by two genera: *Semnopithecus* and *Trachypithecus*

Hanuman langurs exhibit much morphological variation throughout their range, which is reflected in the multitude of classification schemes proposed to resolve its taxonomic status.

Classification schemes are follows:

Pocock, 1928., 1939 conducted one of the earliest systematic reviews of Hanuman langur classification. He considered Hanuman langur as a single species, *Semnopithecus entellus*, with 14 subspecies including *S. e. schistaceus, S. e. entellus, S. e. ajax, S. e. achilles, S. e. hypoleucos, S. e. priam, S. e. dussumieri, S. e. thersites, S. e. achates, S. e. iulus, S. e. aeneas, S. e. priamellus, S. e. elissa, and S. e. anchises*

Hill, 1939 split the Hanuman langur into 4 species (*Semnopithecus schistaceus, S. entellus, S. hypoleucos, and S. priam*). He elevated Pocock's Semnopithecus entellus entellus to species level with no subspecies and placed the remaining subspecies in the other 3 species. Accordingly he placed the Himalayan subspecies *hector, schistaceus, achilles, ajax,* and *lanius under Semnopithecus schistaceus.* Similarly, he placed the subspecies from South India and Sri Lanka, *priam, thersites,* and *anchises* under *Semnopithecus priam*, and *hypoleucos, aeneas,elissa, iulus, dussumieri* and *achates under S. hypoleucos.*

Finally, **Brandon-Jones , 2004** split the Hanuman langur into 2 *species, Semnopithecus entellus and S. priam, with 9 subspecies. Here, Semnopithecus entellus has 7 subspecies: S. e. schistaceus, S. e. entellus, S. e. ajax, S. e. hector, S. e. achates, S. e. hypoleucos, and S. e. anchises whereas S. priam has 2 subspecies: S. p. priam and S. p. thersites.*

3.2. Distribution

Hanuman or common langurs (family Cercopithecidae, subfamily Colobinae) are the most widely distributed nonhuman primates in South Asia (Choudhury, 2007; Napier & Napier, 1967). They are dispersed throughout most of India and Sri Lanka (Ellerman & Morrison-Scott, 1966; Oates et. al., 1994), and are also established in parts of Pakistan, Nepal (Oates et al. 1994; Roonwal 1984), Bhutan, and Bangladesh (Choudhury, 2007). They occur in a wide range of habitats from arid regions on the edge of the desert in Rajasthan to the rain forests of Western Ghats and at altitudes of 100–4270 m above mean sea level (msl) in the Himalayas (Bishop, 1978; Hrdyn, 1977). Central Himalayan Langur occurs in the monsoon forests of North Western Frontier province of Pakistan through the high Himalayan elevations (1,500-4,000 m) of India, Nepal and up to the Sankosh river in Bhutan. In China it is found in the Tibetan regions in Bo Qu, Ji Long Zang Bu and the Chumbi valleys.

3.4. Morphology

Central Himalayan Langurs are mid-sized gray langurs that dark brownish with a whitish head, ventrum, upper hindquarters, and tip of the tail. Further, they have a larger body size than others among the gray langurs (Groves, 2001). The combined head and body lengths of both sexes average 68.9 cm (27.1 in) but females are typically somewhat smaller than males. Males average 17.7 kg (39.0 lb) and females average 15.8 kg (34.8 lb) (Roonwal, 1979) (Plate 1).

IV. MATERIALS AND METHODS

4.1. Field methods

4.1.1. Activity and feeding

The activity pattern was studied during 4 months between December 2014 and March 2015. A troop was locating in the morning near their sleeping site, generally cliffs, and following them until they entered another sleeping site that evening. Contact with the monkeys, however, could never be guaranteed, in December after snowfall Forest troop was not contacted regularly despite hundreds of hours of search. Thus, December data from Forest troop is limited to observations. I followed the Forest troop approximately 26 days with 2363 individual's records. I have collected 587 focal samples (146 hours) from this troop. Village Troop was followed for approximately 42 days with 5853 individual records. Totally 603 focal samples were collected (150 hours) during the study period.

Observations were generally carried out by naked eye or through binoculars (Olympus 8x40), general activity (feed, travel, rest, play, social interactions and others) by scan sampling at 5-minute intervals (Altmann 1974). Activity for each visible individual was recorded at the moment it was first observed .During scans, which continued for 10 minutes. Feeding activity by focal animal sampling at 5- minute intervals (Altmann, 1974) .For particular individual that was feeding during focal, I recorded the food species and plant

Six types of activities were distinguished, as follows:

1. **Resting:** When an animal was not moving either its fore- or hind-limbs. This category included times during which an animal was looking about, huddling with others or resting.
2. **Moving**: When an animal was locomoting.
3. **Feeding**: When an animal was actively manipulating potential food items, ingesting or masticating food.

4. **Social interactions**: When an animal was grooming a conspecific, or was being groomed by another animal, copulating, fighting.
5. **Play**: Chasing, wrestling, stalking, pulling, running or hanging from branch of a tree.
6. **Other**: any activity that was not covered by the other categories; included rock licking, soil licking, aggressive interactions, alarm-calling.

Besides the environmental parameters such as Temperature, Humudity and Light intensity were collected by using digital Thermometer, digital hygrometer and digital Lux meter respectively.

4.1.2. Classification of dietary items

Leaves were catagorized as flush leaves (generally dormant winter buds) young and mature leaves (based on size, color and texture) Fruit was categorized as ripe or unripe based on color and size, or dehiscence state. Bloomed flowers and flower buds were categorized under flowers .other plant part and food item include papers.

4.1.3. Phenology

For the phonological samples in 12 vegetation plots (total area = 1.2ha) during the study period .Sampling took place fortnightly each month, for four months. Totally 12 vegetation plots were laid for 6 in each troop and the size was 20× 50 m in the habitat of Village and habitat of Forest Troop. All trees with diameter at breast height of 10 cm or greater were measured. Voucher specimens from each species were collected and later identified by plant scientists at the Hemwti Nandan Bahuguna Garhwal University, Uttarakhand. India.

4.2. Analytical methods

4.2.1. Activity budgets

For the estimation of the percentage time spent on each activity per quarter per individual from instantaneous scans using the formula:

$$Taqi = (naqi / Nqi)\ x\ 100$$

where, *Taqi* = Percentage time spent on activity *a* in quarter *q* by individual *i*,

$naqi$ = number of records of activity a in quarter q for individual i, and

Nqi= number of records of all activities in quarter q for individual i.

4.2.2. Diet

I estimated the percentage time spent feeding on different plant species and food types for each season from focal animal continuous sampling using the formula:

$$Pa = (na / N) * 100$$

where, na is the total amount of time spent feeding on species or type a, and

N is the total feeding time observed for that season.

I calculated species-specific contribution to forest production using:

$$Wi = (\Sigma Ai / ni) * Bi$$

where Wi is the weighted abundance of a plant part, Ai is the phenological score, ni is the number of individuals, and Bi is the basal area per hectare in square meters, all for species i (modified from Dasilva 1994). Summed totals for all species, and each plant part, were utilized for estimates of overall vegetation abundance.

To estimate preference for or avoidance of plant species in diet, I used the Vanderploeg and Scavia Relativized Electivity Index (Ei*) (Lechowicz, 1982), given as

$$Ei* = [Wi - (1/n)] / [Wi + (1/n)]$$

$$where, Wi = Ei' / \Sigma Ei' \; and$$

$$Ei' = ri / pi,$$

Where, ri is the percentage time spent feeding on species i, pi is the percentage availability of species i and n is the total number of species in diet. The Vanderploeg and Scavian Relativized Electivity Index (Ei*) is based on the selectivity coefficient (Wi). It ranges from -

1 to +1, where a zero value indicates random feeding, 1 indicates maximum preference and -1 indicates maximum avoidance (Lechowicz, 1982)

4.3. Statistical Methods

In order to test differences between males and females and difference between adults and immature in the frequencies of different activities, I used the G-test of independence (McDonald, 2014) . Four samples blocks (0600-0900hrs, 0900-1200hrs, 1200-1500hrs, 1500-1800hrs) were categorised among that data blocks. SPSS 16 and Microsoft excel were used for data analysis. For all statistical analyses considered the hourly percentage of each activity. I calculated Sperman rank correlation coefficient among the present activities and temperature (n=176 and n=176 forest, village respectively)

Spearman rank correlations assessed the relationship between extractive foraging in Central Himalayan langurs and the abundance or consumption of plant part. These plant part classes include flush leaves, young leaves, mature leaves, unripe fruits, ripe fruits and flowers.

V. OBSERVATIONS AND RESULTS

5.1. Time -activity budget and time-activity pattern

There were two different troops identified and recorded the time activity budget viz., the Forest Troop and Village Troop, between December (2014) to March (2015). Both troops were followed at routine time period intervals during this period. By using scan sampling for a total of 65 days on these two troops, with 2363 individual records for Forest Troop and 5,853 records for Village Troop. The number of scan sampling days in a month varied from 10 to 15 days, and total number of scan records for Forest Troop was 273, 727 822, and 541 for December 2014, January, February and March 2015, respectively and 2955, 1265, 985 and 648 for Village Troop for December 2014, January, February and March 2015, respectively.

5. 1.1. Time-activity budget

5.1.1.1. *Forest Troop*

Resting was the major activity of all age/sex classes for all months. Next, they spent between 30% - 35% of the time moving followed by feeding. All age/sex classes spent similar amounts of time resting and feeding, while time spent moving was also similar for all age/sex classes except females, who spent less time moving. Playing activity was only performed by the subadults and juveniles. Females spent more time on social interactions (allogrooming and autogrooming) compared to other age/sex classes. Other activities included geophagy and aggressive interactions. (Figure 5.1.1.1.)

5.1.1.1.1. Time-activity budget differences between Males and Females

Adult males and females were observed to perform 5 different types of activities which were classified as per the Methods and were categorized in to 6 major activities. Differences in activities between males and females were compared using the G-test of Independence. There was no significant difference in time spent between male and female in these activities (Figure 5.1.1.1.1). (G-test, $p > 0.15$, df = 5)

Figure 5.1.1.1. Comparison of age/sex class differences in the activity budget of Forest Troop. The bars represent weighted average of each activity with standard error, n= 458.

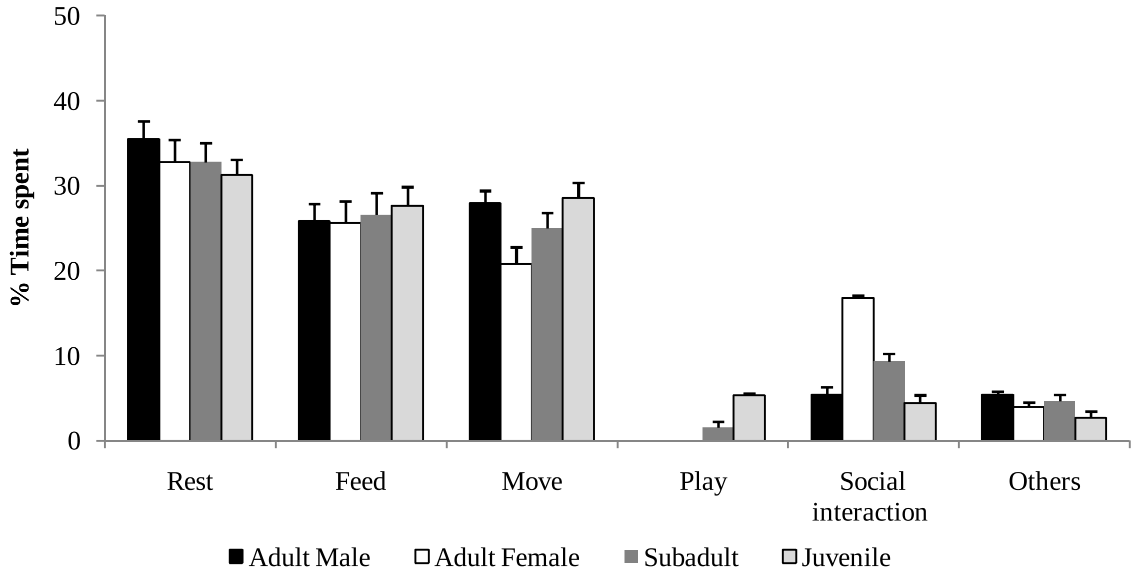
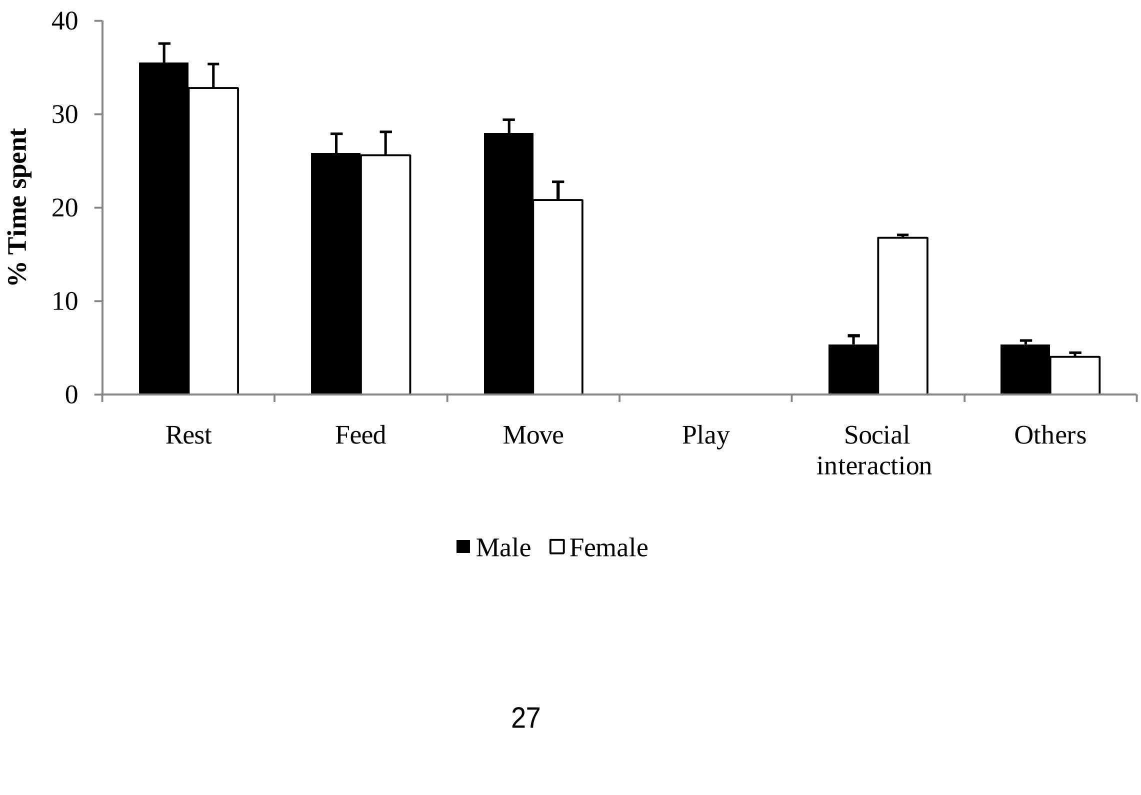


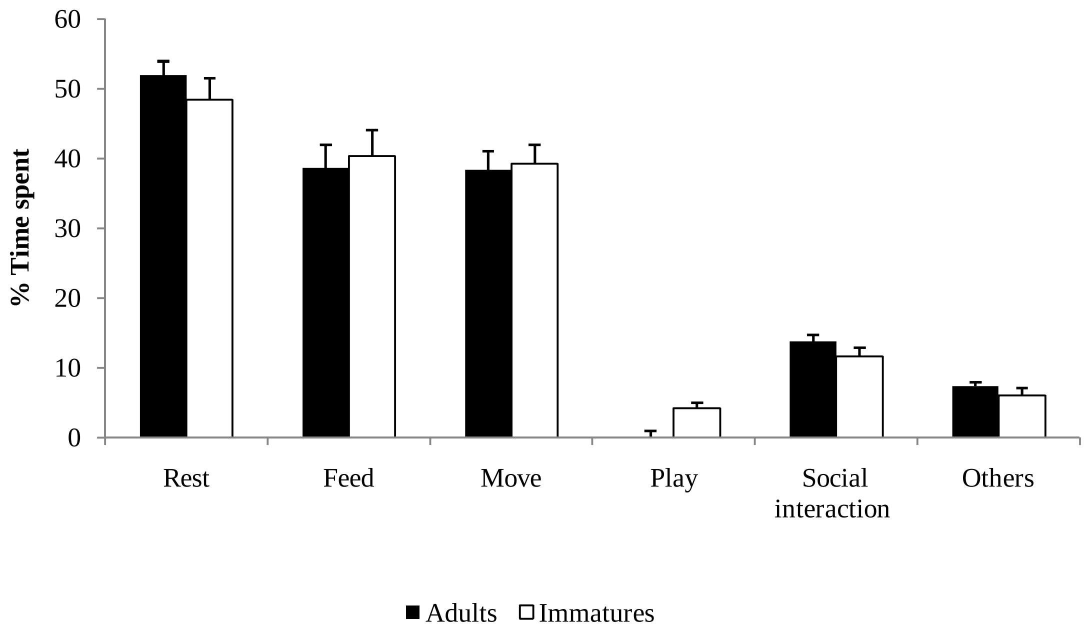
Figure 5.1.1.1.1. Comparison of adult male and female differences in the activity budget in Forest Troop. The bars represent weighted average of each activity with standard error, n= 218.



5.1.1.1.2. Time-activity budget difference between adults and immatures

The adults and immatures in Forest Troop displayed all 6 major types of activities. Differences between adult and immature activities were compared by G-test of Independence. It was found that, adults and immatures showed significant difference in time allotted for different activities (G-test, Strong trend, p = 0.07, df =5). Immatures spent more time on feeding and less time for resting than the adults. There is also a major difference in time spent in play activity between immatures and adults, because play was only performed by immatures (Figure 5.1.1.1.2.).

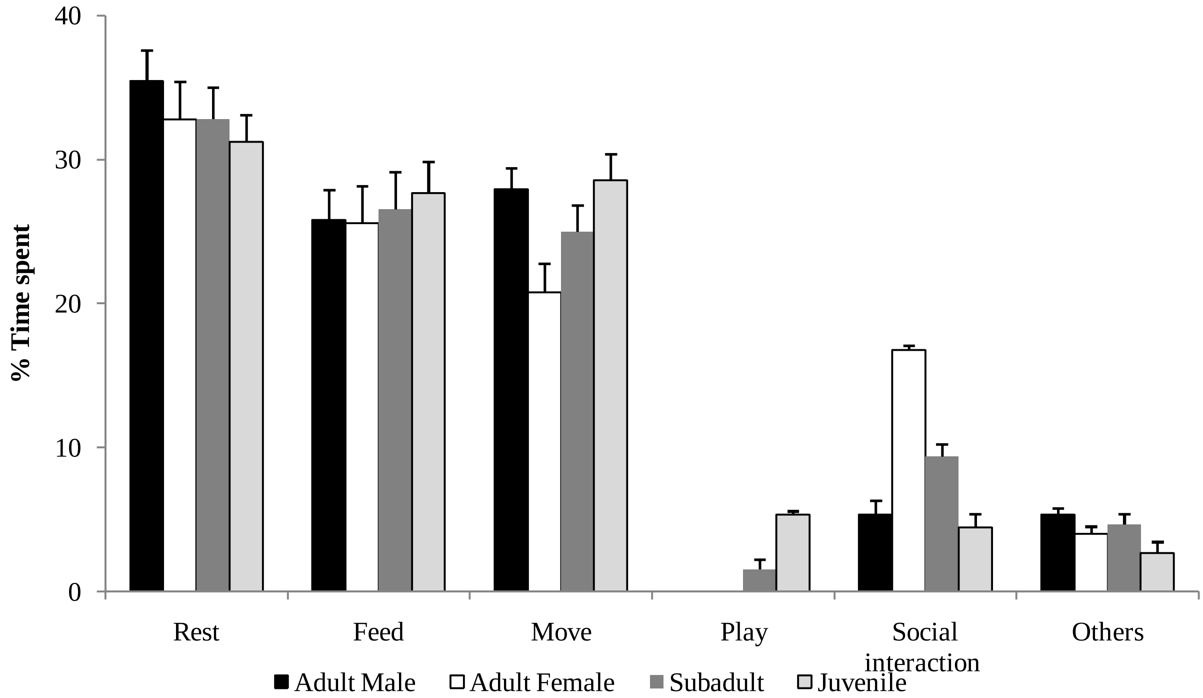
Figure 5.1.1.1.2. Comparison of adult and immature differences in the activity budget of Forest Troop. The bars represent weighted average of each activity with standard error, n= 458.



5.1.1.2. *Village Troop*

Resting was the major activity of different age/sex classes in all months. Next, they spent between 30% - 35% of the time on moving followed by feeding behaviour and social interactions. Adult males spent more time on resting behaviour compared to the juveniles and subadults while adult females spent a similar time on resting as subadults. All age/sex classes spent similar amounts of time for feeding and moving, except females who spent less time for the moving. Play activity was only performed by subadults and juveniles. Females spent more time on social interactions (allogrooming and autogrooming) compared to other age/sex classes. Other activities included geophagy and aggressive interactions. (Figure 5.1.1.2.)

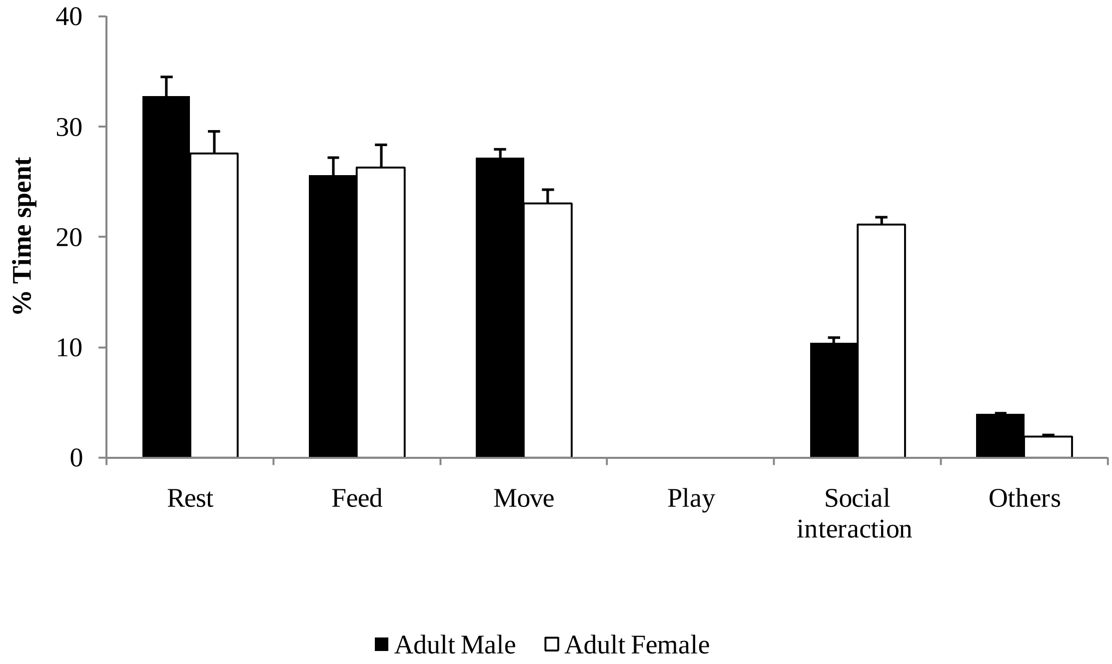
Figure 5.1.1.2. Comparison of age/sex class differences in the activity budget of Village Troop. The bars represent weighted average of each activity with standard error, n= 583.



5.1.1.2.1. Time-activity budget differences between Males and Females

Adult males and females were observed to perform 5 of the 6 different activity types, classified as per the Methods. Overall there were no obvious differences in total time spend feeding, moving and resting by males and females. However, females did spend more time engaged in social interactions compared to males (Figure 5.1.1.2.1). Differences between male and female activities were compared by the G-test of Independence. There was no significant difference between male and female activities (G-test, $p > 0.10$, df = 5).

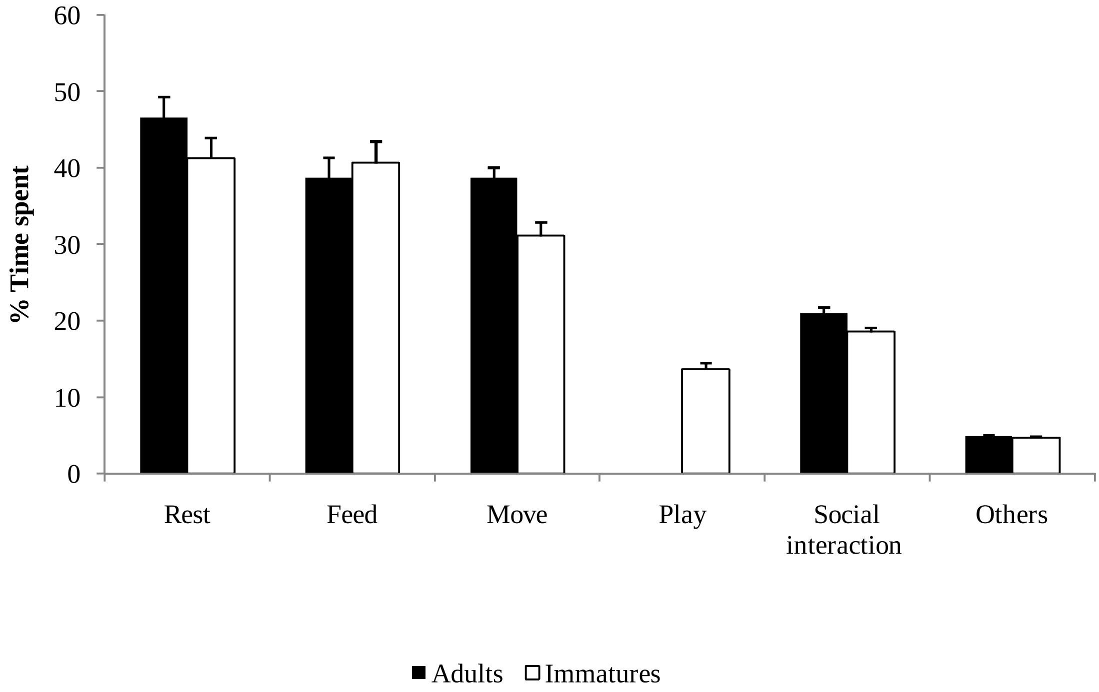
Figure 5.1.1.2.1 Comparison of adult male and female differences in the activity budget of Village Troop. The bars represent weighted average of each activity with standard error, n= 281.



5.1.1.2.2 Time-activity budget difference between adults and immatures

Adults and immatures in the Village Troop displayed all 6 major types of activities. Differences between adults and immatures were compared by the G-test of Independence. It was found that, adults and immature showed statistically significant differences in time spent in these activities (G-test, p = 0.01, df =5). Adults spent more time resting, moving and engaging in social interactions then did immatures. Adults did not play. Immatures spent time playing during the resting time of adults. Adults and immatures spent similar amounts of time in feeding and other activities (geophagy and aggressive interactions) (Figure 5.1.1.2.2).

Figure 5.1.1.2.2. Comparison of adult and immature differences in the activity budget of Village Troop.. The bars represent weighted average of each activity with standard error, n= 583.

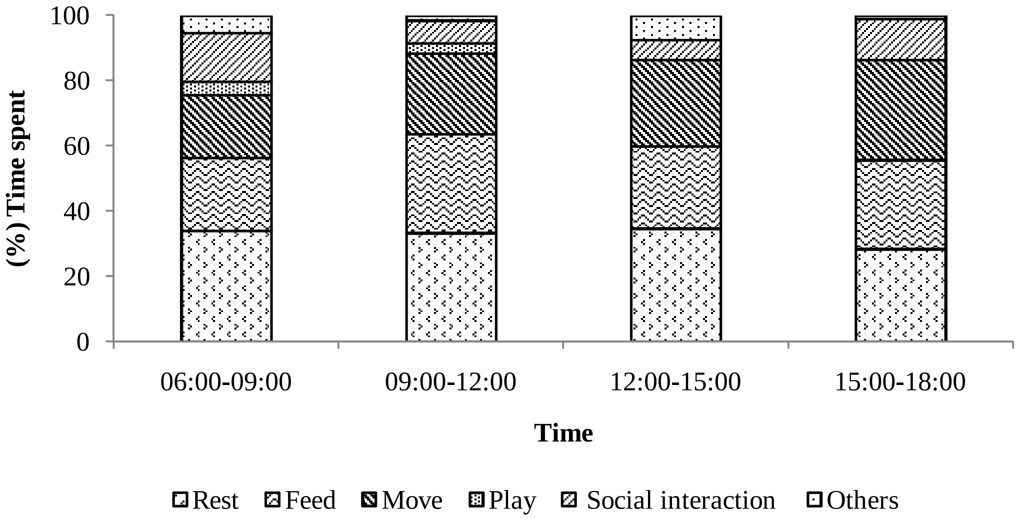


5. 1. 2. Time-activity pattern

5.1.2.1. *Forest Troop*

Altogether, during daylight hours, Forest troop showed a peak in feeding activity between 09:00-12:00 (Figure.5.1.2.1). Time spend resting was longer around midday (09:00-15:00 hrs.) than in early mornings and evenings. Time spent moving was less in the morning, but increased during the day and again became less in the evening. Play activity was most commonly observed between 06:00-09:00 hrs., while other activities such as rock-licking was more commonly observed during midday (12:00-15:00hrs). Forest troop spend much time engaged in social interactions i.e. allogrooming and sexual interactions, only in the moring and evening hours. Time spend in various activities was statistically significantly different different periods of the day (G-test, $p<0.05$, df=15). Play and social interactions occurred most frequently in the morning hours (06:00-09:00 hrs.), because at this time adults spent much time engaged in social interactions, leaving much time for immatures to play.

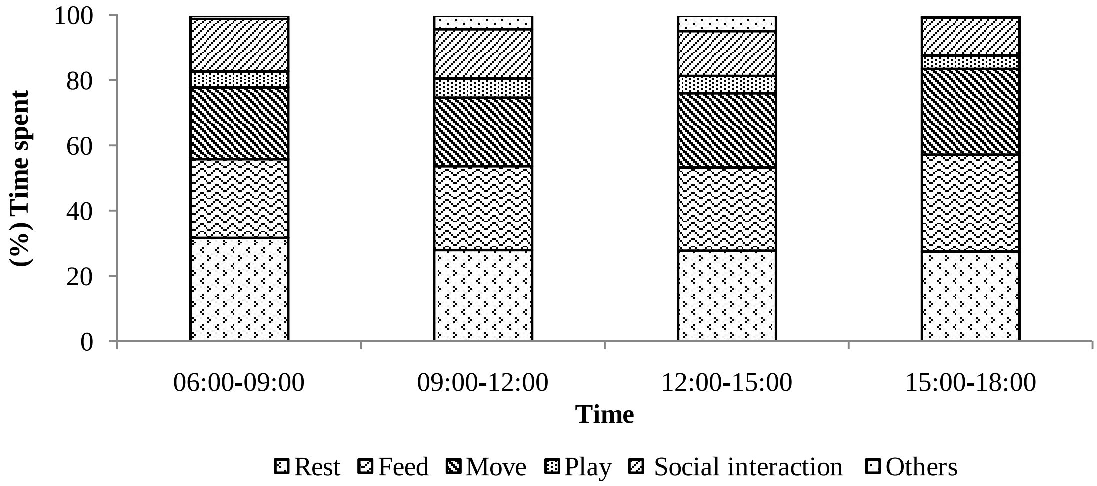
Figure 5.1.2.1. Distribution of time spent in activities across the day in Forest Troop
The bars represent time spent on various activities in each time block. n= 458.



5.2.2.2. *Village Troop*

Differences in time spent in major activities by Village troop were not statistically significant across the day (G-test, $p > 0.5$, df = 15). Time spent feeding was almost equal in all time blocks, with only slightly greater amounts of time spent during the evening, because langurs spent much time feeding at end of the day just before sleeping. Same order was observed for resting and moving it is almost identical in the each time block. Village troop showed a peak in social interaction during the morning (06:00-09:00 hrs.), and engaged in other activities such as soil and rock licking only at mid day (09:00-15:00 hrs.). Immatures spent equal amounts of their time playing in the morning and evening (Figure, 5.2.2.2.).

Figure 5.2.2.2 Distribution of time spent in activities across the day in Village Troop
The bars represent time spent on various activities in each time block. n= 583



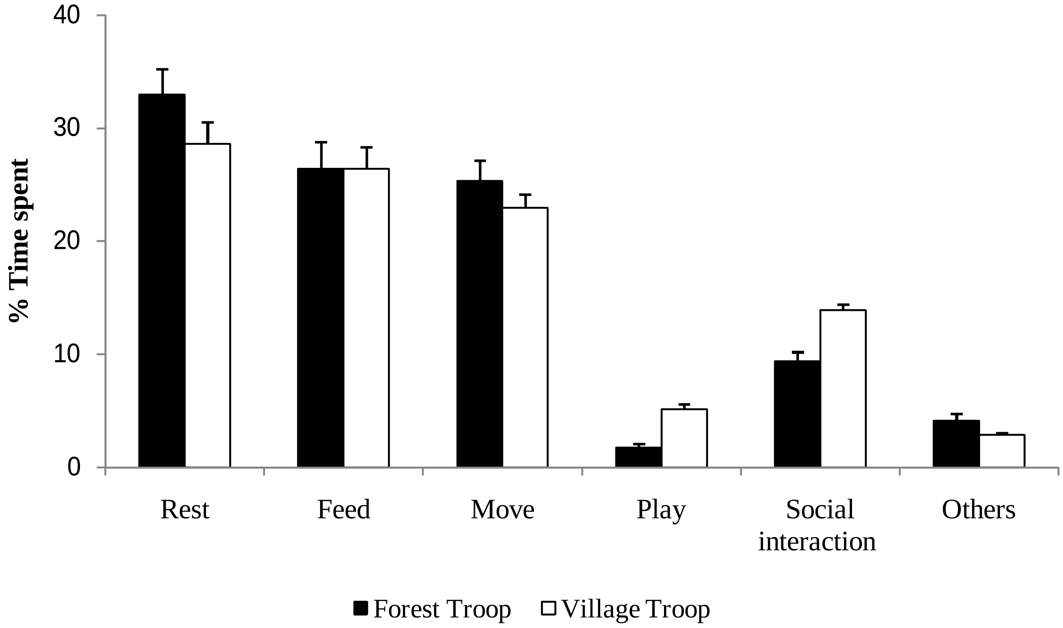
.

5.1.3 Comparison of activity budgets between Forest and Village Troops

5.1.3.1 Overall time-activity budgets

The Forest and Village Troops showed statistically significant differences in the amount of time allocated to their major activities (G-test, $p < 0.01$, df = 5). Forest Troop spent more time resting, compared to Village Troop. Both troops were observed to spend identical amounts of time feeding. Forest Troop moved more to search in feeding patches compared to Village Troop, which could easily reach feeding patches nearby the village or inside the agricultural fields. Time spend in play was greater in Village Troop then Forest Troop, and in both troops was one of the main activities performed only by immatures. It is interesting to note that another key activity, social interaction, only performed by adults, was lower in Forest Troop than Village Troop (Figure 5.1.3.1).

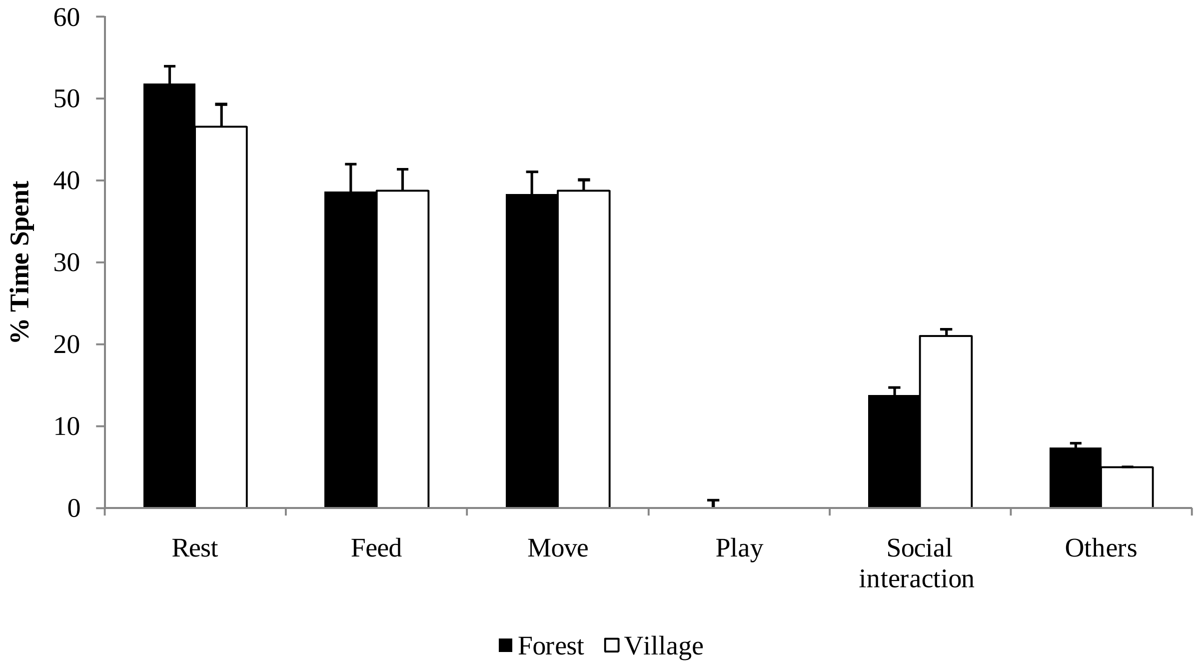
Figure 5.1.3.1. Comparison of the activity budgets of Forest and Village Troops.
The bars represent weighted average of each activity with standard error, Forest Troop, n=458, Village Troop, n= 583.



5.1.3.2 Adults time-activity budget

Village and Forest Troops showed almost identical temporal distributions of their major activity patterns. There were no statistically significant differences (G-test, $p>0.5$, df=5). Forest Troop adults spent slightly more time resting, compared to the Village Troop (Figure 5.1.3.2.). Social interactions were performed more by Village Troop then the Forest Troop. Time spent in other activities such as licking rock and soil eating was a little greater in Forest Troop then Village Troop, perhaps because during winter when food resources were scare for Forest Troop adults, who may be getting certain minerals from the soil and rocks, while Village Troop adults had good access to higher quality resources from horticultural and agricultural crops.

Figure 5.1.3.2. Comparison of the activity budgets of Forest and Village Troops adults. The bars represent weighted average of each activity with standard error, Forest Troop, n=218, Village Troop, n= 281.



5.1.3.3. Immature time-activity budget

Time spent in each activity was statistically significantly different between the immatures of Forest and Village Troops (G-test, P<0.025, df=5). Time spend on feeding by immatures of both troops were similar (Figure 5.1.3.3.). Forest Troop immatures spent more time resting compared to the Village Troop. Another major activity, moving was observed more in Forest Troop immatures. Play activity in the Forest Troop immatures was quit low compared to that of immatures in Village Troop, and they also did not spend much time engaged in social interactions. The demand for feeding was equal for the immatures of both troops, but to fulfil that demand Forest Troop immatures spent more time travelling to get access to good food resources, taking away from time that could be spent on social and play activities.

Figure 5.1.3.3. Comparison of the activity budgets of Forest and Village Troop immatures. The bars represent weighted average of each activity with standard error, Forest Troop, n=240, Village Troop, n= 302.

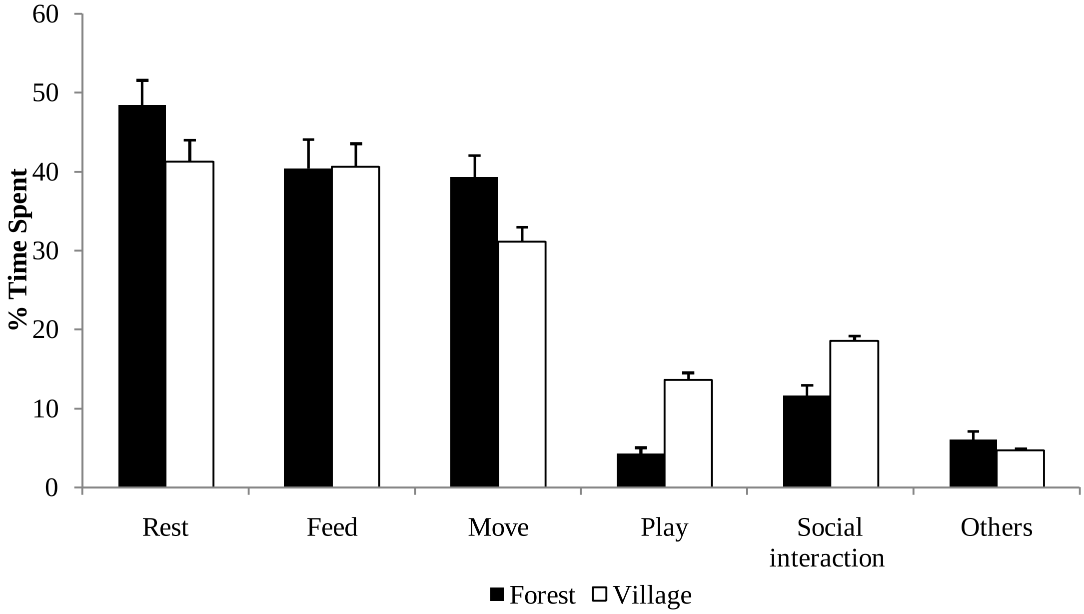
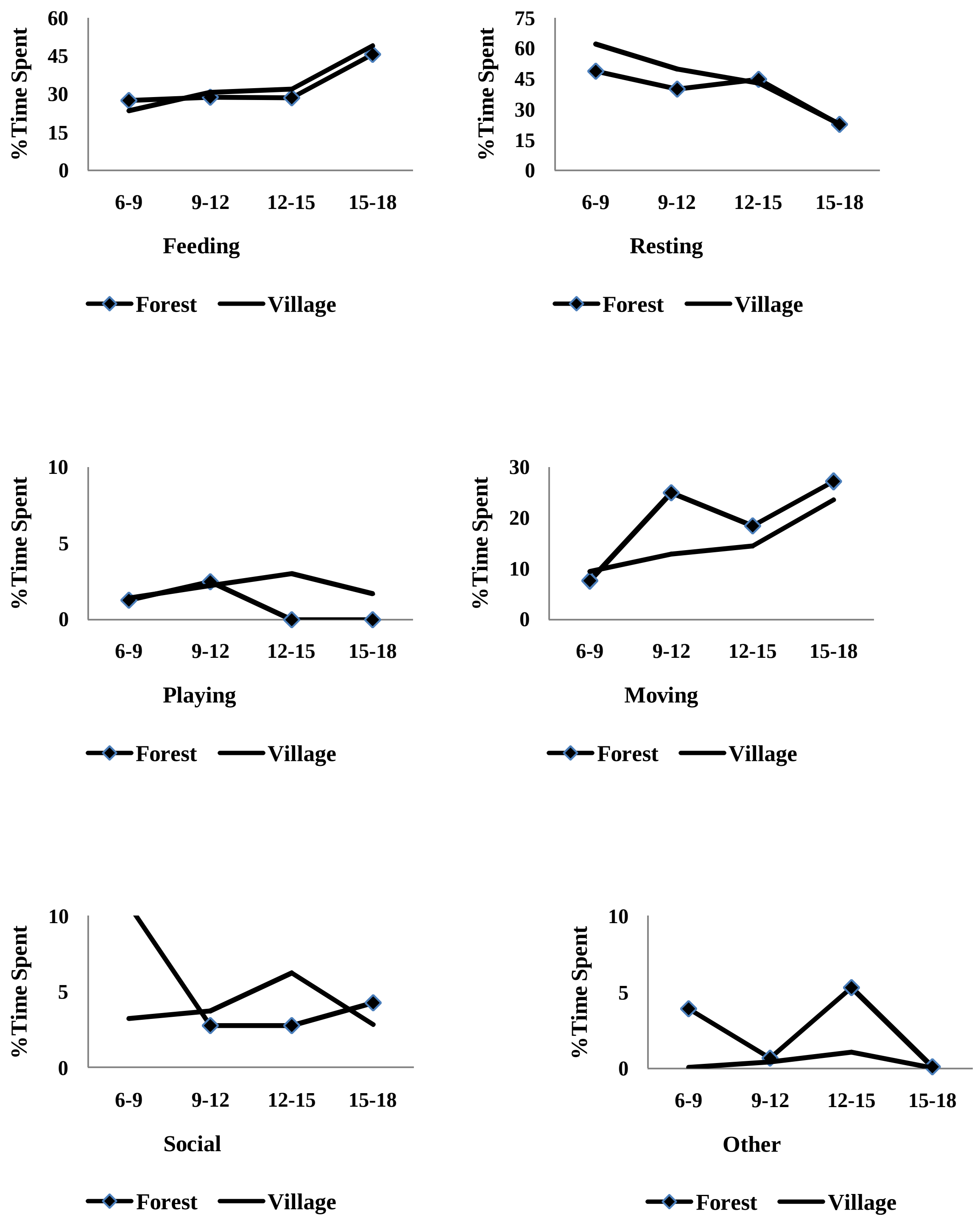


Figure 5.3.2. Comparison of the activity budgets of Forest and Village Troops. Each line shows percent time spent on each activity with reference to daily time block. Forest Troop, n=458, Village Troop, n= 583.



5.2. Influence of environmental variables on time-activity pattern

5.2.1. Forest Troop

Ambient temperature, relative humidity and intensity of light influenced the activity patterns of the Forest Troop. (Figures, 5.2.1, 5.2.2 and 5.2.3). Liner regression model was applied to check the influence of environmental variables on each activity.

Figure 5.2.1. Distribution of time spent in activities across the day in Forest Troop in relation to ambient temperature. The bars represent time spent on various activities in each time block and the line represents daily average temperature, n= 176.

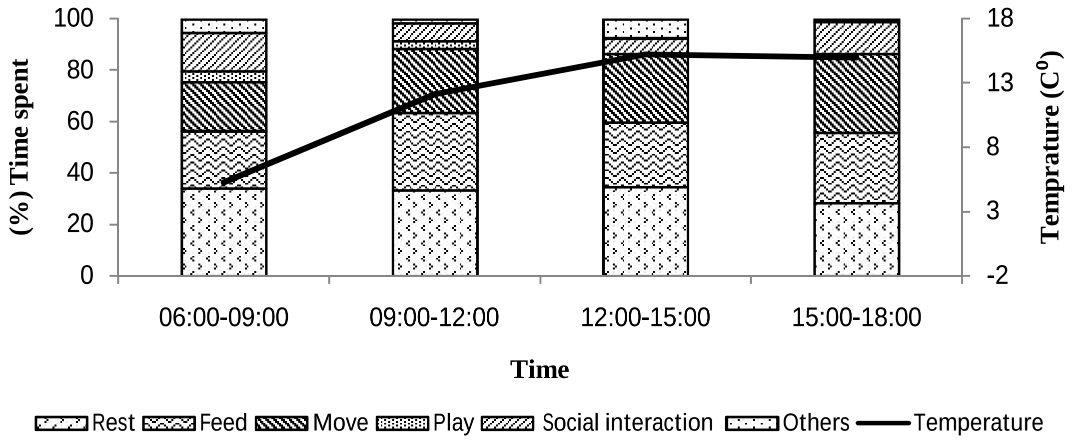


Figure 5.4.2. Distribution of time spent in activities across the day in Forest Troop in relation to relative humidity. The bars represent time spent on various activities in each time block and the line represents daily average humidity, n= 176

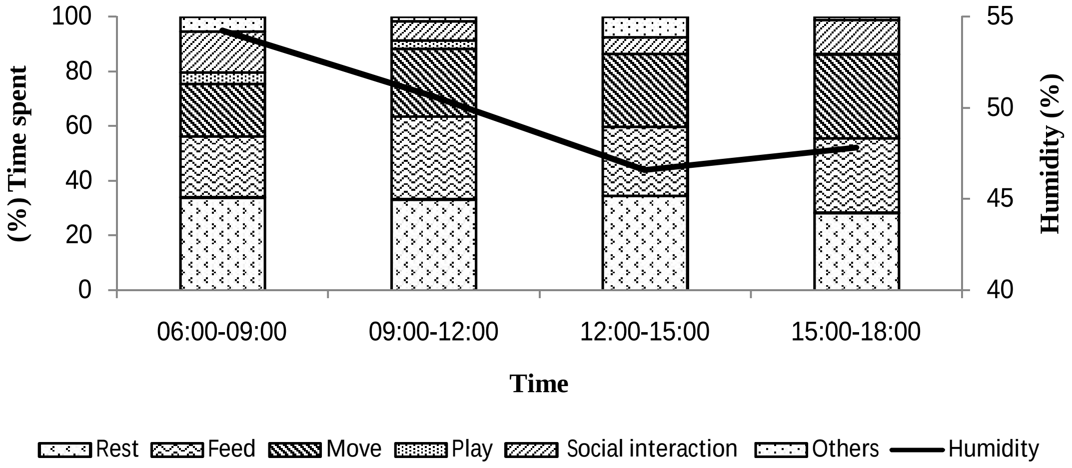
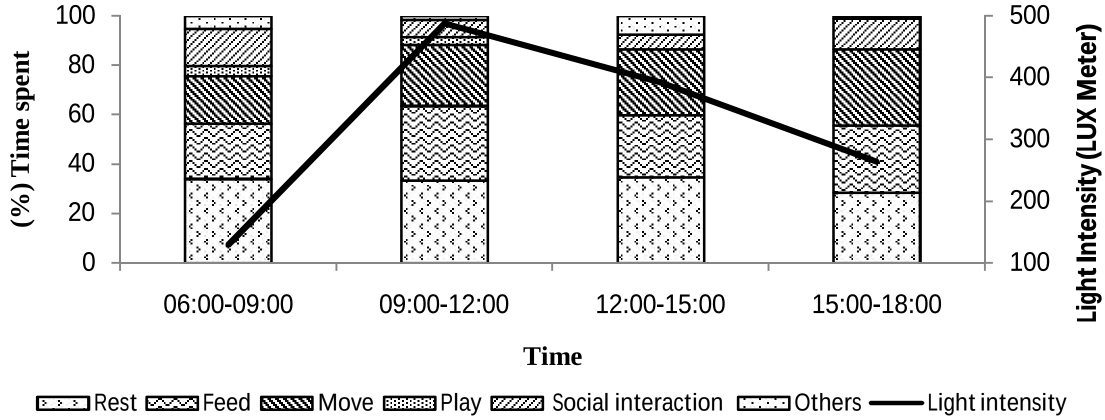


Figure 5.2.3. Distribution of time spent in activities across the day in Forest Troop in relation to light intensity. The bars represent time spent on various activities in each time block and line represents daily average light intensity, n= 176.



5.2.1.1. Influence of ambient temperature, relative humidity and light intensity

Resting

Temperature, humidity and light intensity influenced the occurrence of resting behaviour of the Forest Troop. Resting decreased throught the day with increasing ambient temperature (β=-.455, P=.000). Resting was not influence by the relative humidity (β=-.081, P=.310).Light intensity also influenced resting behaviour. Resting increased with increasing light intensity (β=-.486, P=.000), (Table 5.2.1.1.).

Feeding

Altogether ambient temperature and intensity influenced the feeding activity of the Forest Troop. (Table 5.2.1.1). In a forest habitat during the winter period, langurs tend to feed more in relation to increasing ambient temperature (β=-.679, P=.000) and also feeding increased with decreasing light intensity (β=-.313, P=.000).

Moving

Moving activity was not influence by ambient temperature, relative humidity or light intensity in Forest Troop. (Table 5.2.1.1)

Playing

Play behaviour in the Forest Troop was also not influence by ambient temperature, relative humidity and light intensity in Forest Troop. (Table 5.2.1.1)

Social interactions

Social interactions such as allgrooming and sexual interactions were influenced by ambient temperature (Table 5.2.1.1). Social interactions increased with relation to increasing ambient temperature,(β=-.453, P=.000).

Other activities

Other activities such as soil licking and rock licking decreased with increasing relative humidity in the Forest Troop, (β=-.184, P=.029), (Table 5.2.1.1.).

Table 5.2.1.1. Liner regression modal to understand influence of different environmental variables on activity pattern of Forest Troop, *= significant at 0.05 level, n=176.

S.N	Activity	Ambient temperature		Relative humidity		Light intensity	
		β	p	B	p	β	p
1	Rest	-0.455*	0.000	0.081	0.310	0.486*	0.000
2	Feed	0.679*	0.000	-0.023	0.759	-0.313*	0.000
3	Move	-0.121	0.328	-0.015*	0.857	-0.043	0.709
4	Play	-0.021	0.866	-0.113	0.186	-0.045	0.689
5	Social interactions	-0.453*	0.000	-0.057	0.476	0.101	0.353
6	Others	-0.015	0.900	-0.184	0.029*	-0.189	0.096

5.2.2 Village Troop

Most of Village Troop territory consisted of the anthropogenic farm land. Their activity budget was influence by ambient temperature, relative humidity and light intensity, (Figs. 5.2.2.1, 5.2.2.2 and 5.2.2.3)

Figure 5.2.2.1. Distribution of time spent in activities across the day in Village Troop in relation to ambient temperature. The bars represent time spent on various activities in each time block and the line represents daily average temperature= 176.

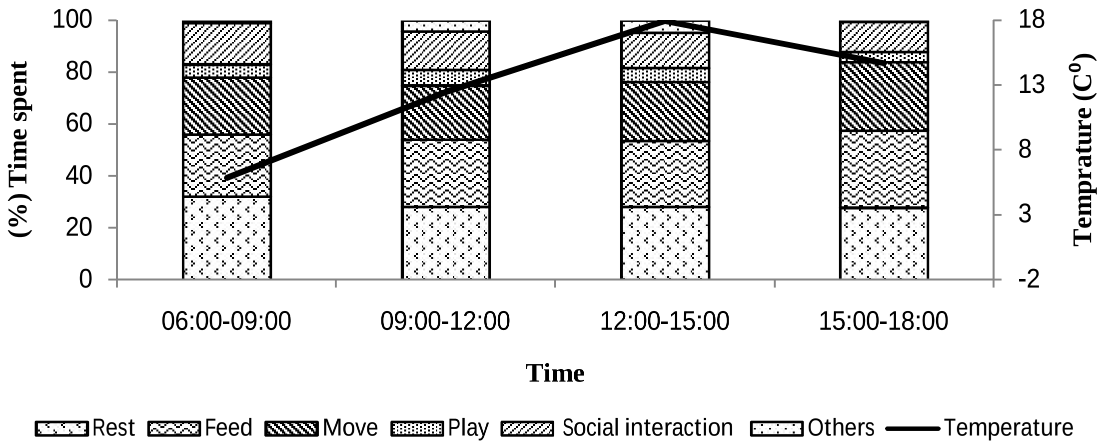


Figure 5.2.2.2. Distribution of time spent in activities across the day in Village Troop in relation to relative humidity. The bars represent time spent on various activities in each time block and the line represents daily average relative humidity, n=176.

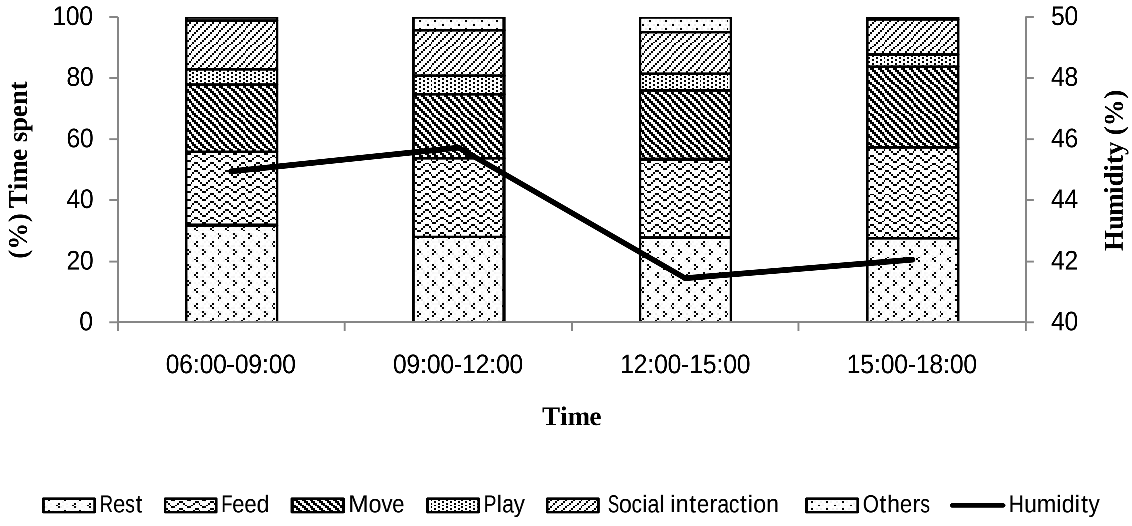
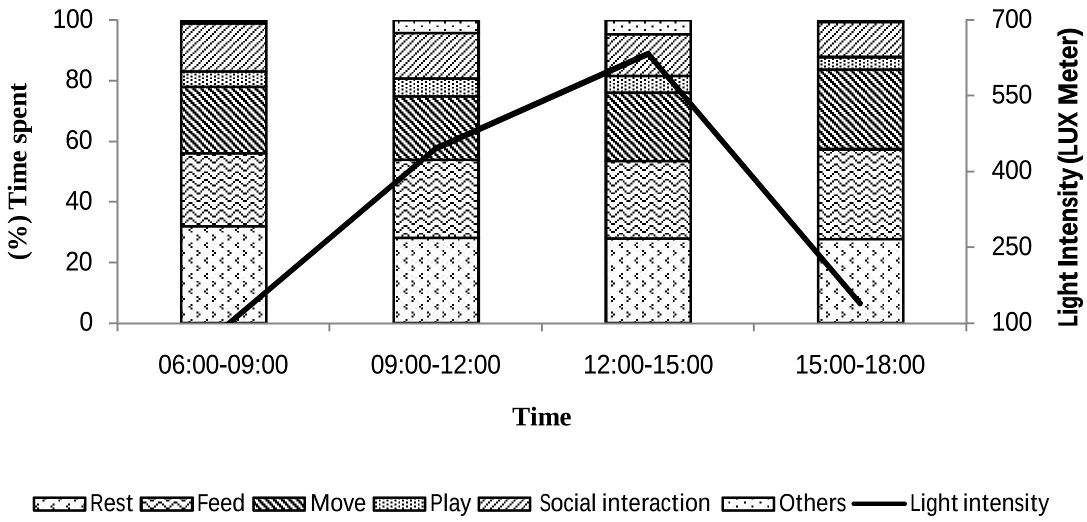


Figure 5.2.2.3. Distribution of time spent in activities across the day in Village Troop in relation to light intensity. The bars represent time spent on various activities in each time block and the line represents daily average light intensity, n=176.



5.2.2.1. Influence of ambient temperature, relative humidity and light intensity

Table 5.2.2.1. Liner regression modal testing the influence of different environmental variables on activity patterns of Village Troop. *= significant at 0.05 level, n=176.

S.N	Activity	Ambient temperature		Relative humidity		Light intensity	
		β	p	β	p	β	p
1	Rest	-0.441*	0.000	-0.255	0.000	0.412*	0.000
2	Feed	0.340*	0.000	-0.048	0.519	-0.328*	0.001
3	Move	0.150	0.106	-0.349*	0.000	-0.266*	0.005
4	Play	-0.072	0.465	-0.102	0.184	-0.191	0.054
5	Social interactions	-0.073	0.464	0.074	0.341	0.063	0.514
6	Others	0.018	0.850	0.106	0.157	0.274	0.005*

Resting

By and large ambient temperature, relative humidity and light intensity influenced the resting behaviour of Village Troop. Resting tended to increase in relation to decreases in ambient temperature, (β=-.441, P=.000). Relative humidity significantly influenced resting. Resting decreased with increasing humidity, (β=-.225, P=.000). Furthermore resting increased in relation to the increase in light intensity, (β=-.225, P=.000), (Table 5.2.2.1.)

Feeding

Feeding was not influence by relative humidity in Village Troop,(Table 5.2.2.1). Altogether feeding was influenced by light intensity and ambient temperature. Feeding tended to increase in relation to increasesing ambient temperature, (β=.340, P=.000) and it's decreased in relation to increasing light intensity, (β=-.328, P=.000).

Moving

Temperature did not influence moving activity. Moving decreased when humidity increased (β=-.349, P=.000). Moving also increased with relation to decreasing light intensity, (β=-.349, P=.000),(Table 5.2.2.1).

Playing

Play behaviour was not influence by ambient temperature, relative humidity or light intensity (Table 5.2.2.1).

Social interactions

Ambient temperature, relative humidity and light intensity did not show any relationship with social interactions, (Table 5.2.2.1).

Other activities

Other activities such as rock and soil licking tended to increase with increasing light intensity, (β=-.274, P=.005). Ambient temperature and relative humidity did not influence these activities (Table 5.2.2.1).

5.3. Diet

5.3.1. Food plant species: Forest Troop

Members of Forest Troop were observed feeding on plant foods from a minimum of 19 families, 26 genera, and 35 species. In December 2014, the most feeding time was spent on *Daphniphyllum himalayense* ripe fruits followed by *Quercus leucotrichophora* unripe fruits, (15.79%) and the ripe fruits of unknown species #22'UK2 (15.79%). In January 2015 they spend the most time feeding on the climber *Tetrastigma spp.*mature leaves followed by UK2 ripe fruits (18.21%) and *Rubusx paniculatus* flush leaves, (6.82%) . In February 2015 the most feeding time was spent on climber *Tetrastigma spp* flush leaves, (42.43%) followed by *Carpinus viminea* flush leaves, (38.31%) and *Rhododendron arboretum* flowers, (4.33%). In March the most feeding time was spent on *Carpinus viminea* flush leaves, (38.37%) followed by *Tetrastigma spp.*, (35.47%) and *Rubusx paniculatus* flush leaves, (5.12%). Other then woody plants, they feed on one moss species root in March. (Table 5.3.1)

Table 5.3.1. Time spent feeding on plant part in relation to the different month from December 2014 to March 2015 by Forest Troop. Where **FL**-flush leaves, **YL**- young leaves, **ML**- mature leaves, **UF**- unripe fruits, **RF**- ripe fruits, **FLW**-flowers, **H**-herb, **S**-shrub, **T**-tree, **C**-climber, **M**-moss.

S. No.	Species Name	Family Name	Vegetation Type	Food item/ parts	% of feeding time			
					Jan (n=101)	Feb (n=212)	Mar (n=57)	Dec (n=34)
1	*Adhatoda zeylanica* Medik.	Acanthaceae	S	ML	0.10	0.55	0.03	-
2	*Hedera nepalensis* K.Koch	Araliaceae	C	UF	6.72	0.98	-	-
3	*Alnus nepalensis* D.Don	Belulaceae	T	FL	-	0.13	-	-

S. No.	Species Name	Family Name	Vege-tation Type	Food item/ parts	% of feeding time			
					Jan (n=101)	Feb (n=212)	Mar (n=57)	Dec (n=34)
4	*Berberis aristata* DC.	Berberidaceae	S	ML	-	0.08	-	-
5	*Carpinus viminea* Wall. ex Lindl.	Belulaceae	T	FL	-	34.88	38.31	-
6	*Cupressus torulosa* D.Don	Cupressaceae	T	RF	0.50	-	-	-
7	*Daphniphyllum himalayense* (Benth.) Müll.Arg.	Daphniphyllaceae	T	RF	6.83	-	-	55.26
8	*Rhododendron arboreum* Sm.	Ericaceae	T	FLW	-	4.33	-	-
9	*Lyonia ovalifolia* (Wall.) Drude	Ericaceae	T	FL	2.31	1.52	-	-
10	*Trifolium repens* L.	Fabaceae	H	YL	-	-	5.45	-
11	*Quercus leucotrichophora* A. Camus	Fagaceae	T	FL	-	0.24	2.79	15.79
12	*Quercus glauca* Thunb.	Fagaceae	T	FL	-	-	0.22	-
13	*Juglans regia* L.	Juglandaceae	T	FL	-	-	0.84	-
14	*Machilus duthiei* King	Lauraceae	T	ML	-	2.38	-	-
15	*Neolitsea pallens* (D. Don) Momiy. & H. Hara	Lauraceae	T	YL	-	0.82	-	-

S. No.	Species Name	Family Name	Vege-tation Type	Food item/ parts	% of feeding time			
					Jan (n=101)	Feb (n=212)	Mar (n=57)	Dec (n=34)
16	*Perse odoratissima* A. Camus	Lauraceae	T	YL	-	2.54	-	-
17	*Stephami sp.*	Menispermaceae	C	ML	6.43	-	-	-
	Stephami sp.	Menispermaceae	C	ML	-	-	2.63	-
18	*Ficus virens* Aiton	Moraceae	T	FL	-	0.17	-	-
19	*Jasminum dispermum* Wall.	Nyctaginaceae	C	YL	-	0.16	-	-
20	*Jasminum officinale* L.	Oleaceae	C	ML	-	-	2.12	-
21	*Arundinella bengalensis* (Spreng.) Druce	Poaceae	G	RT	0.84	0.52	-	-
22	*Prinsepia utilis* Royle	Rosaceae	S	YL	2.58	-	-	-
23	*Puracantha crenulata (Roxb. ex D.Don) M.Roem.*	Rosaceae	T	YL	-	0.49	-	-
24	*Pyrus pashia* Buch.-Ham. ex D.Don	Rosaceae	T	YL	-	0.01	-	-
25	*Rosa brunonii* Lindl.	Rosaceae	S	FL	-	-	2.11	-
26	*Rubus*x *paniculatus* Schltdl. ex Link	Rosaceae	C	FL	-	-	5.12	-

S. No.	Species Name	Family Name	Vegetation Type	Food item/ parts	% of feeding time			
					Jan (n=101)	Feb (n=212)	Mar (n=57)	Dec (n=34)
27	*Rubus*x *paniculatus* Schltdl. ex Link	Rosaceae	C	FL	6.82	3.93	-	-
28	*Rubus ellipticus* Sm.	Rosaceae	S	FL	2.23	2.27	-	-
29	*Debregeasia salicifolia* (D.Don) Rendle	Urticaseae	T	FL	-	-	2.12	-
30	*Tetrastigma spp.*	Vitaceae	C	YL	34.55	43.54	35.47	13.16
31	UK1		T	ML	6.68	-	-	-
32	UK2		T	RF	18.21	-	-	15.79
33	paper		O	-	-	0.47	-	-
34	UK3		S	ML	5.22	-	-	-
35	Moss		M	RT	-	-	2.79	-

5.3.2. Food plant species: Village Troop

Members of Village Troop were observed feeding on plant foods from a minimum of 20 families, 29 genera, and 36 species. In December 2014, the most feeding time was spent on *Prunus cerasoides* young leaves(56.19%) followed by *Pyrus pashia* flush leaves, (9.28%) and*Rubus ellipticus* mature leaves, (8.53%).In January 2015 they spent at the most time feeding on *Quercus leucotrichophora* unripe fruits (39.90%), followed by *Prunus cerasoides* young leaves (20.58%) and *Stephami* spp. mature leaves (8.34%). In February 2015 they spent the most time feeding on *Prunus cerasoides* young leaves (24.93%) followed by *Citrus sp*. 2 ripe fruits (14.82%) and *Pyrus pashia* flush leaves, (9.82%). During the month of March 2015 they spent the most time feeding on *Prunus cerasoides* young leaves followed by *Brassica spp.* flowers (12.40%) and *Hedera nepalensis* unripe fruits (11.21%). Other than woody plants they feed on the roots of one moss species in February and March 2015 (Table 5.3.2.).

Table 5.3.2. Time spent feeding on plant part in relation to the different month from December 2014 to March 2015 by Village Troop. Where, **FL**-flush leaves, **YL**- young leaves, **ML**- mature leaves, **UF**- unripe fruits, **RF**- ripe fruits, **FLW**-flowers, **H**-herb, **S**-shrub, **T**-tree, **C**-climber, **M**-moss.

Sam. No.	Species Name	Family Name	Vegetation Type	Food item/ Parts	% of feeding time			
					Jan (n=128)	Feb (n=103)	Mar (n=30)	Dec (n=36)
1	*Adhatoda zeylanica* Medik.	Acanthaceae	H	RT	4.72	-	-	-
	Adhatoda zeylanica Medik.	Acanthaceae	H	ML	1.75	0.66	-	-
2	*Hedera nepalensis* K.Koch	Araliaceae	C	UF	-	1.43	11.21	-
3	*Alnus nepalensis* D.Don	Belulaceae	T	FL	1.92	-	-	-
4	*Berberis aristata* DC.	Berberidaceae	S	ML	4.10	5.58	3.66	6.93
5	*Brassica sp.*	Brassicaceae	H	FL	-	2.31	12.40	-
	Brassica sp.	Brassicaceae	H	ML	2.43	1.49	-	-

Sam. No.	Species Name	Family Name	Vegetation Type	Food item/ Parts	% of feeding time			
					Jan (n=128)	Feb (n=103)	Mar (n=30)	Dec (n=36)
6	*Rhododendron arboreum* Sm.	Ericaceae	T	FLW	-	-	-	4.80
7	*Quercus leucotrichophora* A. Camus	Fagaceae	T	FL	-	0.34	9.19	2.33
	Quercus leucotrichophora A. Camus	Fagaceae	T	RF	-	2.27	4.41	3.99
	Quercus leucotrichophora A. Camus	Fagaceae	T	UF	39.90	1.74	-	-
8	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	Lauraceae	T	YL	0.31	0.09	0.24	-
9	*Persea odoratissima* (Nees) Kosterm.	Lauraceae	T	YL	-	-	1.24	-
10	*Reinwardtia indica* Dumort.	Linaceae	H	YL	0.72	3.13	5.91	-
11	*Woodfordia fruticosa* (L.) Kurz	Lythraceae	S	FL	-	-	2.73	-
	Woodfordia fruticosa (L.) Kurz	Lythraceae	S	YL	-	5.46	-	-
12	*Grewia optiva* J.R.Drumm. ex Burret	Malvaceae	T	ML	3.40	1.79	1.44	-

Sam. No.	Species Name	Family Name	Vegetation Type	Food item/ Parts	% of feeding time			
					Jan (n=128)	Feb (n=103)	Mar (n=30)	Dec (n=36)
13	*Toona ciilata* M. Roem.	Meliaceae	T	FL	-	-	-	2.96
14	*Stephami sp.*	Menispermaceae	C	ML	8.34	1.90	0.39	-
15	*Ficus sarmentosa* Buch.-Ham. ex Sm.	Moraceae	T	YL	-	1.10	-	-
16	*Ficus virens* Aiton	Moraceae	T	FL	-	0.12	1.70	-
17	*Myrica esculenta* Buch.-Ham. ex D. Don	Myricasea	C	ML	-	2.32	-	-
18	*Jasminum dispermum* Wall.	Nyctaginaceae	C	ML	-	0.10	1.36	1.46
19	*Jasminum officinale* L.	Oleaceae	C	ML	-	0.53	-	-
20	*Arundinella bengalensis* (Spreng.) Druce	Poaceae	G	RT	-	0.11	1.46	-
21	*Sinarundinaria falcata* (Nees) C.S.Chao & Renvoize	Poaceae	G	YL	1.02	-	-	-
22	*Triticum sp.*	Poaceae	G	YL	5.95	9.72	5.61	-
23	*Prunus avium* (L.) L.	Rosaceae	T	YL	-	0.20	0.26	0.24

Sam. No.	Species Name	Family Name	Vegetation Type	Food item/ Parts	% of feeding time			
					Jan (n=128)	Feb (n=103)	Mar (n=30)	Dec (n=36)
24	*Prunus cerasoides* Buch.-Ham. ex D.Don	Rosaceae	T	YL	20.58	24.93	23.35	56.19
25	*Pyrus pashia* Buch.-Ham. ex D.Don	Rosaceae	T	YL	-	-	0.30	-
	Pyrus pashia Buch.-Ham. ex D.Don	Rosaceae	T	FLW	-	-	-	3.28
	Pyrus pashia Buch.-Ham. ex D.Don	Rosaceae	T	FL	-	9.82	2.10	9.28
26	*Puracantha crenulata* (Roxb. ex D.Don) M.Roem.	Rosaceae	T	YL	-	-	0.47	-
27	*Rosa brunonii* Lindl.	Rosaceae	C	YL	-	0.52	-	-
28	*Rubus* x *paniculatus* Schltdl. ex Link	Rosaceae	H	FL	-	-	0.42	-
29	*Rubus ellipticus* Sm.	Rosaceae	S	ML	-	0.58	1.80	8.53
30	*Citrus sp. 1*	Rutaceae	T	YL	-	-	1.00	-
	Citrus sp. 2	Rutaceae	T	RF	-	14.82	5.29	-
31	*Zanthoxylum armatum* DC.	Rutaceae	S	YL	2.59	0.05	0.65	-
32	*Celtis australis* L.	Ulmaceae	T	YL	2.28	0.76	-	-

Sam. No.	Species Name	Family Name	Vegetation Type	Food item/ Parts	% of feeding time			
					Jan (n=128)	Feb (n=103)	Mar (n=30)	Dec (n=36)
33	*Caryopteris odorata* (D.Don) B.L.Rob.	Verbinaceae	H	YL	-	0.37	-	-
34	UK		H	RT	-	4.17	0.68	-
35	Moss		M	RT	-	1.45	0.72	-
36	paper		O	-	-	0.15	-	-

Table 5.3.3.1. Percent time spent feeding on different species in relation to age/sex classes by Forest Troop. **AM**-adult male, **AF**-adult female, **SAM**-subadult male, **SAF**- subadult female, **JUV**- juvenile, n=404 focals

S.No.	Name of the Species	AM	AF	SAM	SAF	JUV
1	*Adhatoda zeylanica*	1.54	0.01	0.14	-	0.02
2	*Alnus nepalensis*	0.39	-	-	-	-
3	*Arundinella bengalensis*	1.59	-	0.60	0.21	
4	*Berberis aristata*	-	0.16	-	-	-
5	*Cupressus torulosa*	-	-	-	-	0.60
6	*Carpinus viminea*	23.70	24.60	23.20	20.79	1.58
7	*Daphniphyllum himalayense*	10.56	4.25	3.14	30.90	1.59
8	*Debregeasia solicifolia*	-	-	-	2.58	-
9	*Ficus virens*	-	-	0.39	-	-
10	*Flimalrandia tetrasperma*	-	1.91	1.17	2.58	-

S.No.	Name of the Species	AM	AF	SAM	SAF	JUV
11	*Hedera nepalensis*	2.03	4.06	1.65	-	0.15
12	*Jasminum officinale*	1.90	2.32	0.26	-	0.08
13	*Jasminum dispermum*	-	-	1.89	-	-
14	*Juglans regia*	-	-	-	1.01	-
15	*Lyonia ovalifolia*	-	2.37	1.17	4.21	-
16	*Machilus duthiei*	-	-	-	-	1.50
17	*Neolitsea pallens*	1.49	1.94	2.34	-	-
18	*Pyrecantha crenatata*	-	-	0.03	-	-
19	*Prinsepia utihs*	2.92	-	-	-	-
20	*Perse odoratissima*	2.10	-	2.75	-	1.59
21	*Quercus leucotrichophora*	1.49	1.88	2.16	5.15	1.59
22	*Quercus glauca*	-	-	0.12	-	-
23	*Rubus ellipticus*	2.32	0.58	0.31	1.35	0.60
24	*Rosa brunoni*	-	-	1.13	-	-
25	*Rubus paniculatus*	8.06	5.66	4.65	-	0.19
26	*Rosa brunoni*	-	0.16	-	2.14	-
27	*Rhododendron arboreum*	-	-	2.97	-	9.52
28	*Stephami spp.*	-	-	3.65	-	1.54
29	*Ttifolium repens*	1.49	0.93	-	1.56	
30	*Tetrastigma spp.*	36.31	38.66	41.39	21.76	41.03
31	*UK1*	-	-	-	0.81	-
32	*UK2*	2.11	6.87	4.50	2.58	10.35
33	*paper*	-	-	-	2.38	-
34	*Moss*	-	-	1.54	-	-

5.3.3. Diet composition of different age/sex classes

5.3.3.1. Forest Troop

Adult males were observed feeding on 15 species out of the total 34 recorded food species. Adult males spent the most time feeding on *Tetrastigma spp.*, (36.31%) followed by *Carpinus viminea,* (23.70%) and *Daphniphyllum himalayense*, (10.56%). Adult females were observed feeding on 16 species out of 34. Adult females spent the most time feeding on *Tetrastigma spp.,* (38.66%) followed by *Carpinus viminea* (24.60%) and UK2 (6.87%). Subadult males were observed feeding on 23 species out of 34.Subadult males spent the most time feeding on *Tetrastigma spp.,* (23.20%) followed by *Carpinus viminea,* (41.39.%) and *Rubus paniculatus,* (4.65%).Subadult females were observed feeding on 15 species out of 34.Subadult females spent the most time feeding on *Daphniphyllum himalayense,* (30.90%) followed by *Carpinus viminea,* (20.79%) and *Tetrastigma spp.*, (21.76%). Juveniles were observed feeding on 15 species out of 24. Juveniles spent the most time feeding on *Tetrastigma spp.*, (41.03%) followed by *Daphniphyllum himalayense,* (15.08%) UK2, (10.35%). (Table 5.3.3.1)

5.3.3.2. Village Troop

The adult males were observed feeding on 23 species out of 36. Adult males spent the most time feeding on *Triticum spp,* (17.73%) followed by *Prunus cerasoides,* (15.43%) and *Citrus sp*2., (12.05%). Adult females were observed feeding on 20 species out of 36. Adult females spent the most time feeding on *Prunus cerasoides,*(31.43%) followed by *Quercus leucotrichophora,* (10.20%) and *Pyrus pashia*, (9.50%). Subadult males were observed feeding on 11 species out of 36.Subadult males spent the most time feeding on *Tetrastigma spp,* (20.72%) followed by *Prunus cerasoides,* (18.30%) and *Pyrus pashia,* (16.54%). Subadult females were observed feeding on 19 species out of 36.Subadult females spent the most time feeding on *Tetrastigma spp*, (37.81%) followed by *pashia*, (9.87%) and *Woodfordia fruticosa*, (6.73%). Juveniles were observed feeding on 26 species out of 36. Juveniles spent the most time feeding on *Tetrastigma spp*, (30.75%) followed by *Prunus Avium*, (11.28%) and *Pyrus pashia*, (9.48%).(Table 5.3.3.2)

Table 5.3.3.2. Percent time spent feeding on different species in relation to age/sex classes by Village Troop. Where **AM**-adult male, **AF**-adult female, **SAM**-subadult male, **SAF**-subadult female, **JUV**- juvenile, n=297.

S.No.	Plant Species	AM	AF	SAM	SAF	JUV
1	*Adhatoda zeylanica*	0.43	0.20		1.69	2.04
2	*Alnus nepalensis*	0.78		-	-	-
3	*Arundinella bengalensis*	-		-	2.96	1.18
4	*Rosa brunoni*	0.14	0.39	-	-	-
5	*Berberis aristata*	1.73	3.67	1.86	6.27	9.99
6	*Brassica spp.*	9.66	4.99	9.15	6.20	4.18
7	*Celtis australis*	1.79				0.71
8	*Cinnamomum tamala*	0.13	0.24	1.13	0.47	
9	*Citrus spp. 1*	1.77	-	-	-	-
10	*Citrus spp. 2*	12.05		9.15	5.93	-
11	*Caryopteris odorate*	-		-	-	1.57
12	*Ficus virens*	-		-	-	1.96
13	*Grewia optiva*	6.42	-	-	-	1.33
14	*Hedera nepalensis*	3.68	7.34	4.58	5.93	0.97
15	*Jasminum officinale*	-	0.70	-	-	-
16	*Jasminum dispermum*	2.91	0.38		6.01	1.32

S.No.	Plant Species	AM	AF	SAM	SAF	JUV
17	*Perse odoratissima*	-		-	-	-
18	*Prunus Avium*	0.46	-	0.84	0.31	11.28
19	*Perse odoratissima*	-	0.09	-	-	1.86
20	*Prunus cerasoides*	15.43	31.32	18.30	0.07	5.03
21	*Pyrus pashia*	0.52	9.50	16.54	9.87	9.48
22	*Quercus leucotrichophora*	9.92	10.20	0.32	6.66	4.93
23	*Reinwardtia indica*	7.78	0.46	4.58	-	0.93
24	*Rubus ellipticus*	1.50	2.59	-	0.20	0.39
25	*Rubus paniculatus*	0.75	-	-	-	1.56
26	*Rhododendron arboreum*	-	1.44	-	0.20	-
27	*Stephami spp.*	-	1.48	-	-	0.62
28	*Sinarundinaria falcata*	-		-	0.96	-
29	*Triticum spp.*	18.73	5.08	-	1.46	0.41
30	*Tetrastigma spp.*	2.91	1.44	20.72	37.81	30.75
31	*Toona cilata*	-		-	-	1.25
32	*Woodfordia fruticosa*	-		-	6.73	7.35
33	*zanthoxylum arnatum*	0.15	-	-	0.28	-
34	UK	-	2.13	-	-	5.52
35	Moss	-	2.16	-	-	0.64
36	paper	0.34	-	-	-	5.58

Table.5.3.3.3 Top five tree species in the Forest Troop diet, listed by average monthly percentage of feeding records, density/ha, Shannon Weiner diversity index (H’), average basal area and average tree height from the four-month sample.

Tree Species	**Density/ha.**	**H'**	**Basal area m^2/ha.**	**Tree height(m)**	**% diet**
Alnus nepalensis	40.00	0.10	0.704	14.31	0.08
Carpinus viminea	16.67	0.06	0.649	9.94	27.10
Daphniphyllum himalayense	181.67	0.16	0.578		1.62
Machilus duthiei	11.67	0.05	1.184	10.45	1.46
Quercus leucotrichophora	6.67	0.03	4.931	19.05	0.56

Table 5.3.3.4. Top five tree species in the Village Troop diet, listed by average monthly percentage of feeding records, density/ha, Shannon Weiner index (H’), average basal area and average tree height from the four-month sample.

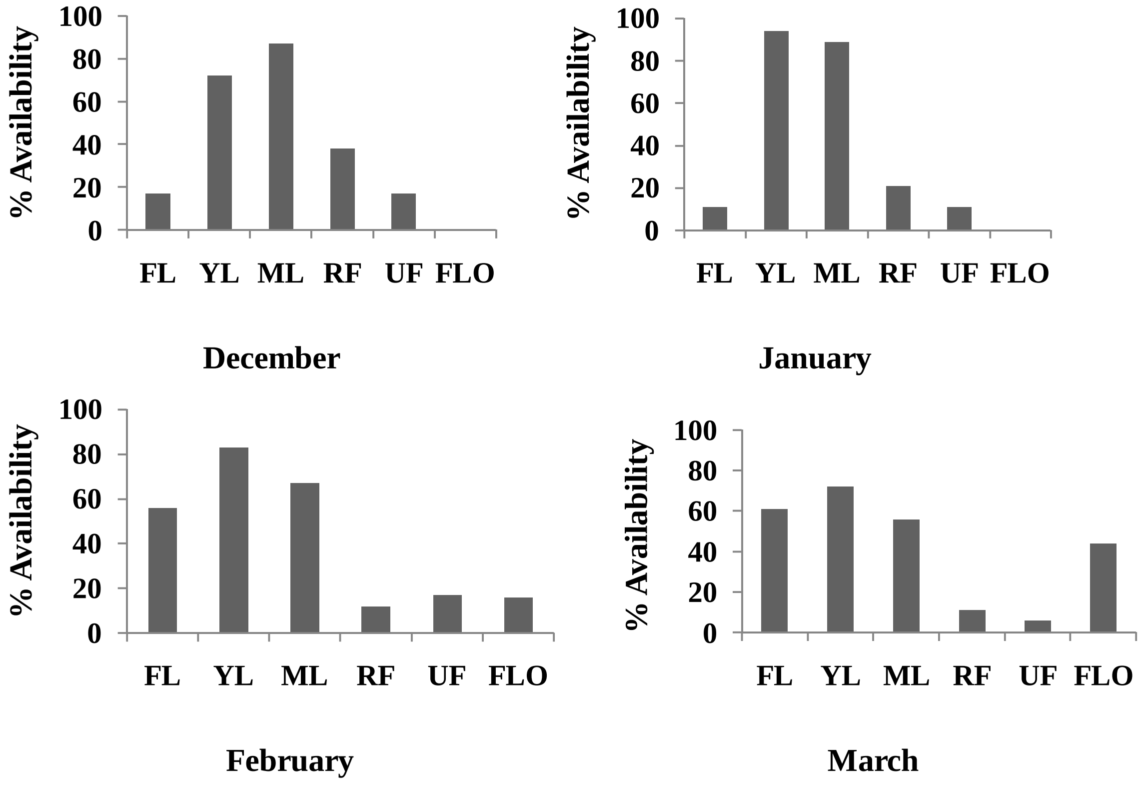
Tree Species	**Density/ha**	**H'**	**Basal area m^2/ha**	**Tree height(m)**	**% diet**
Citrus myrtifolia	33.33	0.10	0.003	5.56	8.70
Prunus cerasoides	5.00	0.03	0.006	10.52	27.42
Pirus pashia	26.67	0.09	0.004	4.63	6.75
Quercus leucotrichophora	110.00	0.16	0.007	10.41	10.62
Rhododendron arboreum	1.67	0.01	0.010	7.62	0.52

5.4. Diet Selections

5.4.1. Phenological change and diet selection

With regards to the phenological change diet selection, totally 733 trees in the home range of Forest Troop and 958 trees in the home range of Village Troop, through the winter and pre-monsoon months of December 2014, January, February and March 2015. The presence of flush leaves, unripe fruits, ripe fruits and flowers remained unaltered for all the months during the study period. The data for each month was analysed separately and showed that in December, the proportion of trees covered by mature leaves was highest, followed by young leaves and ripe fruits. This pattern of phenology continued through January; the only difference being that the proportion of trees with young leaves increased. The presence of ripe fruits was highest in December 2014 and January 2015 and lowest in February and March 2015. The presence of flush leaves was low in December and January but increased in February and March. In December 2014 and January 2015 the presence of flowers was low and highest in March 2015, (Figure 5.4.1.)

Figure 5.4.1. Percent availability of plant parts during different months of the study period for both habitats. The figures from left to right show the availability of plant parts for December 2014, January 2015, February 2015 and March 2015 respectively. Where **FL**-flush leaves, **YL**-young leaves, **ML**- mature leaves, **RF**- ripe fruit, **UF**- unripe fruit, **FLO**- flower.% Availability = proportion of monitored trees having that plant part x 100 %



5.4.1.1. Forest Troop

In December 2014 the majority of the diet was made up of ripe fruits (86.84%), particularly from *Machilus duthiei* (Table 5.4.1.1), which was available 38% during month of December 2014 followed by mature leaves (13.16%), with an availability score of 87% (Figure 5.4.1.).

Likely fallback foods include climber mature leaves (especially *Tetrastigma spp.*.). This resource is available all year, but is regularly exploited only in winter.

During the month of January 2015 the first leaf flush made up much of the diet (34.16%; Table 5.4.1.1). The flush leaves, taken concurrently, of *Carpinus viminea* was by far the most important spring food item, followed distantly by the mature leaves (55.20%) of *Tetrastigma spp.* Availability of mature leaves and flush leaves were 89% and 11% respectively.

In February 2015 marked the increased availability of flush leaves and mature leaves. Availability was 67% and 56% for mature and young leaves respectively. *Carpinus viminea*,*Tetrastigma* spp.was the primary species explored for flush and mature leaves respectively. February was the highest period of flower availability and made up 4.35% of the diet, which was the highest among all months. *Rhododendron arboretum* was the most important flowering tree in this month and had a 56% availability score.(Table 5.4.1.1).

In March 2015, the majority of the diet consisted of flush leaves (49.39%) and the availability score of flush leaves was highest (61%). In this month only flush, young, and mature leaves availability was present, so they started feeding on the root of an unknown moss species (2.79%; Table 5.4.1.1).

Figure 5.4.1.1 percent contribution of each plant part during December 2014 –March 2015 in Forest Troop diet.

	Percentage of diet*						
Months/Food items	**FL**	**YL**	**ML**	**RF**	**UF**	**FLO**	**RT**
December	0	0	13.16	86.84	0	0	0
January	34.16	2.58	55.20	0.50	6.72	0	0.84
February	41.06	4.03	49.05	0	0.99	4.35	0.52
March	49.39	7.56	40.25	0	0	0	2.79

*(**FL**-flush leaves, **YL**- young leaves, **ML**- mature leaves, **UF**- unripe fruits, **RF-** ripe fruits, **FLW-** flowers and **RT-** root.

5.4.1.2. Village Troop

For the month of December, the majority of the diet was made up of mature leaves (86.84%) particularly from *Berberis aristata*(Table 5.4.1.2.), followed by young leaves particularly from *Prunus cerasoides* which had an availability score of72%.

In January , the first leaf flush made up much of the diet (25.52%) (Table 5.4.1.2). The flush leaves, taken concurrently, of *Alnus nepalensis* followed distantly by the mature leaves (46.02%) of *Stephami sp.* Availability of mature leaves and flush leaves were 89% and 11% respectively.

During February the marked increase in availability of flush leaves and mature leaves was noted. Availability was 67%, 56% for mature and young leaves respectively. *Pyrus pashia* and *Triticum* sp.;the primary species explored for flush and mature leaves respectively. February showed the highest flower availability and made up 15.13 %of diet which is the highest score among the months. *Rhododendron arboretum* was the most important flowering tree in this month and had a 56% availability score. (Table 5.4.1.2.).

But during the month of March , the majority of the diet was made up with mature leaves (56.43%) and availability of mature leaves was highest (56%). In this month they were feeding on flowers as well (8.08%) which is available at 44% specially *Pyrus pashia* and *Rhododendron arboretum* was (Table 5.4.1.2.).

Figure 5.4.1.2. The relative contribution of each plant part during December 2014 –March 2015 in the diet of Village Troop.

	% Percentage of diet						
Months/Food items	***FL**	**YL**	**ML**	**RF**	**UF**	**FLO**	**RT**
December	13.41	20.06	43.71	3.02	8.57	7.21	4.03
January	25.52	14.95	46.02	2.28	3.18	2.31	5.73
February	18.71	8.65	39.03	4.41	11.21	15.13	2.86
March	14.58	16.92	56.43	3.99	0	8.08	0

*(**FL**-flush leaves, **YL-** young leaves, **ML**- mature leaves, **UF**- unripe fruits, **R**F- ripe fruits, **FLO**- flowers and **RT**- root).

5.4.2 Abundance and diet selection

A comparison of the weighted abundance of a food item and the percent of time spent on it clearly shows that both the groups fed more on food items that were more abundant (Table 5.4.2.1.). To the extent there was some selection of food items not related to abundance. However, among those food items that were fed on disproportionately more, there was a stronger correlation between abundance and time spent feeding.

5.4.2.1. Forest Troop

Positive correlations between consumption and abundance (r= 0.598, p<0.000) was found for flush leaves (Table 5.6.2.1).No significant positive correlations were detected for young leaves and mature leaves. This shows that the abundance of young leaves and mature leaves did not influence the selection of either stage of leaves available. Unripe and ripe fruit positively correlated with abundance (r=0.759, p<0.000), (r=0.996, p<0.000). Flower consumption correlated positively with their abundance (r=0.660, p<0.000). (Tables 5.4.2.1)

.

Table 5.4.2.1. Relationship between consumption and abundance of the top six tree species food items of Forest Troop between December 2014-March 2015.

Tree Species	Plants Parts											
	FL		YL		ML		RF		UF		FLW	
	Wi	%Fe	Wi	%Fe	Wi	%Fe	Wi	%Fe	Wi	%Fe	Wi	%Fe
Alnus nepalensis	0.704	0.08	1.057	0	0.704	0	0	0	0	0	0	0
Daphniphyllum himalayense	0.144	5.00	0.578	0.00	2.311	0.55	0.144	15.91	0.144	0.81	0	0
Carpinus viminea	1.297	40.73	0	0	0.162	0	0	0	0	0	0	0
Neolitsea pallens	0	0	0.171	5.08	0.683	0	0	0	0	0	0.171	20.09
Quercus leucotrichophora	2.509	1.56	3.346	0	13.383	0.00	0.836	4.55	0.836	1.31	0	0
Quercus glauca	2.465	0.11	8.629	0	17.258	0	0	0	1.233	0.00	1.233	0

***Wi**- weighted abundance and **Fe**- % time spent on feeding. Where **FL**-flush leaves, **YL-** young leaves, **ML**- mature leaves, **UF**- unripe fruits, **R**F- ripe fruits, **FLO-** flowers

Table 5.4.2.2. Relationship between consumption and abundance of top six tree species parts of Forest Troop during December 2014- March 2015.

Tree Species	**Plants Parts**											
	FL		**YL**		**ML**		**RF**		**UF**		**FLW**	
	Wi	**%Fe**	**Wi**	**%Fe**	**Wi**	**%Fe**	**Wi**	**%Fe**	**Wi**	**%Fe**	**Wi**	**%Fe**
Celtis australis	0.005	0	0.005	2.12	0.007	0	0.001	0	0	0	0.001	0
Citrus spp.	0.002	21.61	0.003	0	0.009	0	0.003	23.00	0	0	0	0
Pyrus pashia	0.005	28.36	0.002	0.19	0.003	0	0.002	0	0	0	0.004	10.16
Prunus cerasoides	0.011	0.00	0.010	68.79	0.002	0	0	0	0.003	0	0	0
Quercus leucotrichophora	0.007	16.62	0.003	0.00	0.026	0	0.010	77.00	0.007	38.74	0	0
Rhododendron arboreum	0	0.00	0.002	0.00	0.029	0	0	0	0	0	0	14.84

*Where **Wi**- weighted abundance and **Fe**- % time spent on feeding. Where **FL**-flush leaves, **YL-** young leaves, **ML**- mature leaves, **UF**- unripe fruits, **R**F- ripe fruits, **FLO**- flowers

Table 5.4.2.3. Spearman Rank correlation for weighted abundance and consumption of plant parts for the Forest and Village Troops during the study period. **FL**-flush leaves, **YL-** young leaves, **ML**- mature leaves, **UF**- unripe fruits, **R**F- ripe fruits, **FLO**- flowers and *= significant at the 0.05% level.

Parts eaten	**Forest**			**Village**		
	r	**p**	**n**	**r**	**p**	**n**
FL	0.598*	0.002	24	0.062	0.387	24
YL	-0.062	0.774	24	0.220	0.151	24
ML	0.319	0.064	24	0.129	0.274	24
RF	0.996*	0.000	24	0.738*	0.000	24
UF	0.759*	0.000	24	0.802*	0.000	24
FLO	0.660*	0.000	24	0.843*	0.000	24

5.4.2.2 Village Troop

No correlations between consumption and abundance flush leaves, young leaves and mature leaves, This shows that the abundance of a flush leaves, young leaves and mature leaves did not influence the selection of flush leaves, young leaves and mature leaves. Unripe fruit and ripe fruit positively correlated with the abundance (r=0.738, p<0.000), (r=0.802, p<0.000) Flower correlated positively with the abundance (r= 0.843, p<0.000).) (Tables 5.4.2.2 and 5.4.2.3).

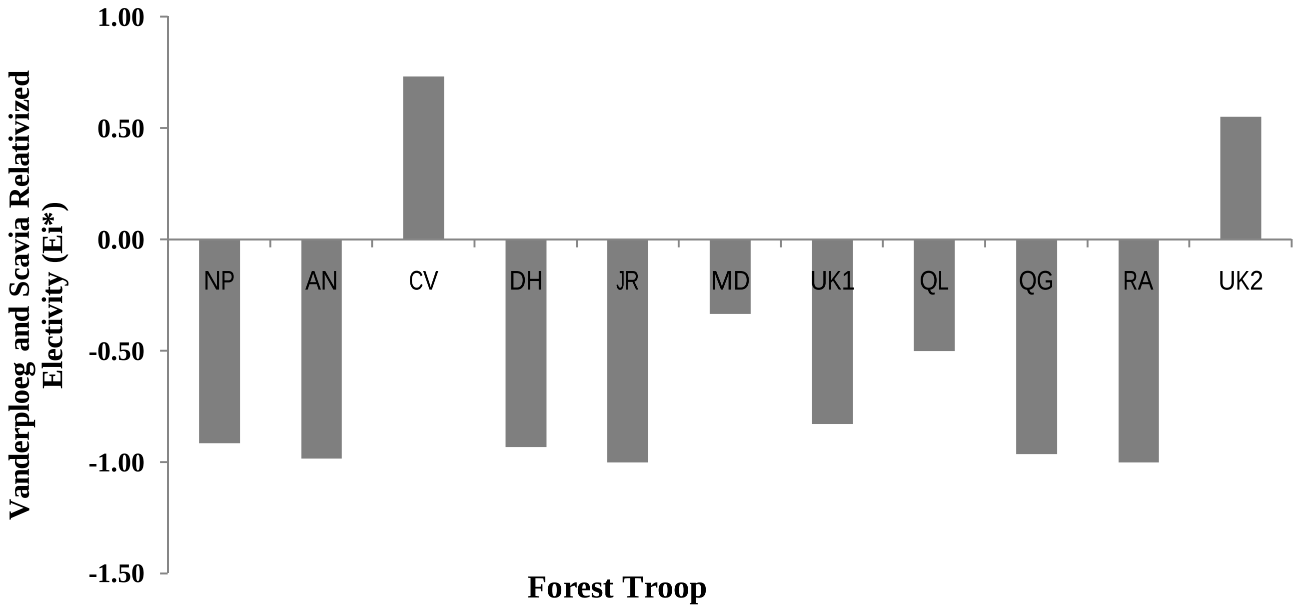
.

5.4.3 Species Preference index

5.4.3.1 Forest Troop

Among the of plants recorded in the forest area the CV and one of the unknown species were predominantly used by the forest troops (Fig. 5.4.3.1).

Figure 5.4.3.1. Electivity indices of plant species using Vanderploeg and Scavia Relativized Electivity (*Ei**), Forest Troop. where NP- *Neolitsea pallens,* AN-*Alnus nepalensis,* CV- *Carpinus viminea,* DH- *Daphniphyllum himalayense,* JR- *Juglans regia,* MD- *Machilus duthiei,* UK1- Unknown1, QL- *Quercus leucotrichophora,* QG- *Quercus glauca,* RA- *Rhododendron arboretum,* UK2- Unknown2

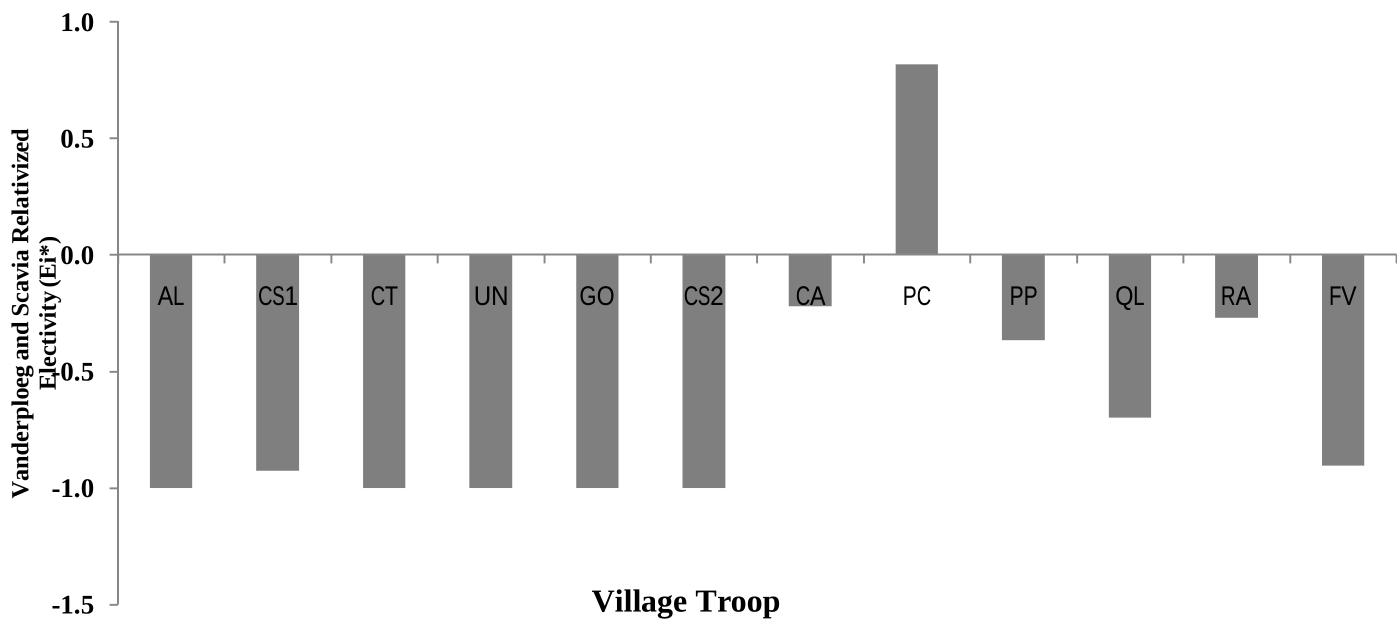


Maximum feeding time was spent on *Carpinus viminea* (68.00%) and UK2 (10.85), the Vanderploeg and Scavia Relativized Electivity Index (*Ei**) indicated that it was a most preferred species while, *Rhododendron arboretum* and *Daphniphyllum himalayense* on which 6.69% and 4.07% of total feeding time was spent were not a preferred species(Figure 5.4.3.1.).

5.4.3.2 Village Troop

Among the top 12 species of plants recorded in the village habitat the animals preferred only one species i.e. *Prunus cerasoides* (Fig.5 4.3.2.1).

Figure 5.4.3.2.1. Electivity indices of plant species using Vanderploeg and Scavia Relativized Electivity (*Ei**), Village Troop. where AL-*Alnus nepalensis,* CS1- *Citrus sp1*,CT-*Cinnamomum tamala*, UN- Unknown, GO- Grewia optiva, CS2-*Citrus sp2*, CA- *Celtis australis*PC-*Prunus cerasoides* PP- Pyrus pashia, QL- *Quercus leucotrichophora*, RA-*Rhododendron arboretum,* FV-*Ficus virens*



Maximum feeding time was spent on *Prunus cerasoides* (47.24%), the Vanderploeg and Scavia Relativized Electivity Index (*Ei**) indicated that it was a most preferred species while, *Quercus leucotrichophora* and *Celtis australis* on which 18.30% and14.00% of total feeding time was spent were not a preferred species (Figure5.4.3.2).

VI. DISCUSSION

6.1. Activity patterns and activity budgets

Long periods of time spent resting and less time spent feeding or moving are typical of leaf-eating colonies (Clutton-Brock, 1977; Stanford, 1991). The Central Himalayan Langur in both study groups spent more time resting (45-50%) and less time moving (35-40%) and feeding (40%). A high percentage of time spent resting has also been observed in many other species of langurs, including the: Himalayan grey langur (*Semnopithecus ajax),* Sayers & Norconk, 2008; Francois' langur (*Trachypithecus francoisi*), Qihai Zhou et. al, 2007. This emphasis on time allocated to resting is likely related to their folivorous diet. Longer resting periods allow for microbial digestion to break down the cellulose in plant cell walls (Oates & Davies, 1994; Nadler et. al, 2003). The process by which these monkeys digest leafy material is somewhat similar to that of a ruminant animal (Oates & Davies, 1994).

Male and female difference in time alotted to activities: This study suggests that in Central Himalayan langurs males and females were constrained to the same level of feeding. It is important to note that although males and females spent similar amounts of time feeding, they may not have had the same diet or have eaten similar amounts of food (Isbell & Young 1993). In both habitats Central Himalayan langur adults spent similar time feeding (40%), and this is because both habitats are equal in terms of biomass (e.g. Watts, 1988).

Adult and immature differences in time alotted to activities: This study suggests that for the Central Himalayan langurs in both habitats (natural forest and anthropogenic farm land), adults spent more time resting and less time feeding compared to the immatures. According to (Cluttion-brock, 1977), "Adults commonly spend proportionally less time feeding and more time resting than immatures in many primate species" and, these observations have been documented in many species , e.g. *Cercocebus albigena* (Waster, 1977), *Alouatta villosa* (Smith, 1977), *Colobus badius* (Cluttion-brock, 1974). Although metabolic rate increases with body weight (kg) 0.75, the energy required per unit body weight decreases (McNab, 1978). Thus, immature individuals have higher energetic and nutritional needs than do adults (Altmann, 1980). One possible explanation for this is that adults, especially females, spent more time allogrooming, while immatures utilise this time to feed when adults groom each other. Not surprisingly, most of the allogrooming was done by females. Greater allogrooming among females in groups is a typical pattern for most of the primate species, in which females form the stable core of the group (Seyfarth, 1980). Female-female relationships in these species involve a complex interplay of kinship, cooperation, and competition (Walters and Seyfarth 1987). It has been suggested that allogrooming is prevalent in these species because it helps to maintain alliances or ease tension as a result of competition within groups (Isbell & Young, 1993).

Time-activity pattern: My results indicate that Central Himalayan langurs have a typical activity pattern of morning and afternoon feeding peaks; with two feeding peaks, one at 0900–1200 h in the morning and the other at 1500–1800 h in the afternoon, with early moring rests (0600-0900), which is an adaptation to variation in the temperature of the environment (Clutton Brock, 1977., Huang & Lu, 1995). In the Western Himalayas, the temperature is very low in the mornings during winter. To avoid these cold temperatures, the simplest and most effective strategy for Central Himalayan langurs is to huddle and get heat from each other. Lowland Hanuman langurs (*Semnopithecus entellus*) have two feeding peaks, at 0600–0930 h in the morning and at 1500–1800 h in the afternoon, with a long period of rest at midday (Ripley, 1970).

Activity budget differences between two habitast: Primates vary their time budget with changing ecological conditions. There are three possible adjustments: (1) to increase the total time allocated to subsistence, (2) to increase the time allocated to feeding, and (3) to minimize energy expenditure and reduce metabolic activity by decreasing time devoted to high cost behaviour or by resting more (Schoener, 1971).

Central Himalayan langurs at the two study sites appeared to have different activity budgets. Although actual feeding time was similar, the Village Troop showed a lower-energy search strategy that minimized foraging and moving. The wild plant-food feeding Forest Troop adopted a more active search strategy, spending more time foraging and moving. These differences likely reflect the abundance and distribution of resources. The Village Troop obtained food from agricultural and horticultural crops. Individuals did not have to move and forage much to obtain sufficient food. In contrast, the habitat of the wild-plant food feeding Forest Troop was affected by human activities and resource exploitation, as well as during that period of time when the availability of leaves was low in the forest, leading to scarce and widely scattered food resources for them, which meant that they had to move continuously to forage successfully. The same behavioural response in foraging and moving time in unprotected areas where food is scarce has been found in groups of wild Barbary macaques in Algeria and in the central high Altas Mountain of Morocco (M´enard & Vallet, 1997). In the subtropics and temperate zone, seasonal vegetation change will directly or indirectly affect the foods available to primates. Langurs in these areas might use different time budget strategies to cope with the seasonal variation of food availability (Hung & Lu, 1995)

Time spent on social interactions, especially allogrooming, was greater in the Village Troop (19%) compared to the Forest Troop (11%). Individuals in groups living in higher-quality habitats might have more time to groom because they were able to obtain foods more quickly than individuals in groups living in poorer quality habitats (Isbell & Young, 1993). However, this is also unlikely because the time spent feeding was equal in both habitats. Ectoparasite densities could be greater in the Village Troop habitat, which could increase the time devoted to allogrooming, to minimize exposure to infection. Alternatively, because in the Higher Himalayas during the winter season in the forest habitat, food is more scare so had to spend more time moving (40%) to search for the good food patchs and thus had less time to spend on social activities. In Village Troopo, individuals spent less time moving (30%) and fed on abundant seasonal horticulture and agricultural crop when leaves were not abundant in the forest, allowing them to spent more time on social interactions. This is consistent with the point that, lower-quality diets may require an increase in the time spent feeding and/or traveling, which may affect time invested in other activities such as resting and socializing (Bronikowski & Altmann, 1996; Dunbar, 1992; Overdorff, 1996).

6.2. Effect of environmental parameters

My study showed that Central Himalayan langur activity patterns were influence by environmental parameters. In the Himalayan region, the temperature decreases during the winter session. Langurs spent more resting in the morning hours 0600-0900, and time spent on this increases when temperature decreases. They start moving and feeding when light intensity increases, i.e. temperature increases. Temprature and light intensity play important roles on feeding activities. My study concluded that Central Himalayan Langur feed more in the evening when light intensity decreases. They feed more in the time block of 0900-1200 when temperature is slightly higher compared to the early morning (0600-0900).

Allogrooming decreases when temperature increases, that is langurs spent more time on social activities when temperature was low, specially in the morning hours because that time they do not spend much time for feeding and moving, due to unfavourable conditions (low temperature and less light).

In open habitats, like farm land, langur resting was influenced by humidity. Feeding decreased when humidity increased. On the other hand, inside the forest, humidity did not play any major role. One potential reason behind this is that humidity increases during rainfall and the Central Himalayan langur is adapted to use of farm land and spent more time inside the agricultural field, moving inside the forest area when it starts raining. Allogrooming was influenced by the ambient temperature in the open farm area, but not by temperature inside the natural forest. When temperature decreased, allogrooming increased in the farm land area, and in the Western Himalayas during the winter, morning and evening, after sunset, are the times when temperatures decrease sharply. This study concluded that those Central Himalayan langurs living in farm lands have specific time for allogrooming and that langurs from natural forest do not show this same kind of behaviour. That is activity patterns were closely linked to environmental difference particular to these two different micro-climates.

6.3. Diet

This study recorded 35 species of plants used for food, represented by 19 families and 26 genera, to be eaten by Central Himalayn langurs living in the forest. The troop living around farmlands similarly used 36 species of plants for food, represented by 20 families and 29 genera. The availability of food, its distribution in the natural habitat and the food value of those ingested plant species are subject to seasonal variation (Ganguly et al. 1964; Tejwani, 1994). Time spent feeding on particular plant species, and the food items to be eaten were selected by their phonological stages, most likely this is influcenced by the extent to which the langurs' nutritional requirements could be fulfilled (Freeland & Janzen 1974; Milton 1980). Consumption of leaves, 82% of diet, probably satisfied their nutritional requirements; young leaves (47% of diet) are reported to contain a high percentage of crude protein (Krishnamani, 1994; Struhsaker, 1975). The abundance of young leaves in the diet of colobine monkeys maintains the high ratio of cell sap to cell wall that results in high digestibility (Oates et. al, 1980). Dietary composition varied considerably monthly during the study period. In the months of lowest food abundance, Central Himalayan langurs exploited a fewer number of food species. In the month of December when availability of flush leaves and young leaves was lowest, langurs feed on a fewer number of species. In December, langurs living in the natural forest feed on 4 of 34 species available, the most abundant being the ripe fruits of *Daphniphyllum himalayense* (55%). One possible reason behind this is that Central Himalayan langurs are optimal foragers, when abundance of leaves is low in the forest, they spend more time feeding on a few species of high nutritional value, instead of searching for multiple food species. Central Himalayan langurs living in farmland area feed on 12 types of species out of 36 in December. Most of the time they were feeding on young leaves of *Prunus cerasoides* (56%), which was absent in the natural forest. My study concluded that at the same time of the year, Central Himalayn langur living in two different habitats shows different diet compositions, based upon the availability of the food items.

Central Himalayan langurs also regularly lick stones and hard calcium carbonate coated walls. It is likely that this is done to obtain their requirements of salts and minerals, such as calcium, magnesium and trace elements, for example copper, (Adhikari & Shrestha, 2011), potentially lacking in the vegetative diet. For this purpose, (Vogel, 1971) noted the presence of special licking places. (Roonwal & Mohnot, 1997) also observed common langurs eating earth, ashes and bones from cremation grounds. (Moe, 1993) found that common langurn (*Semnopithecus entellus*) was one of the most common species on the soil lick during the dry season in the low lands. This was also observed up in the highlands, by Central Himalayan Langurs in the Western Himalayas.

6.4 .Diet Selection

Phenology, appears to play a role in the selection of food items and overall dietary composition. Primates, like other animals, require protein for growth and replacement of tissue, carbohydrate, fat for energy, and various trace elements and vitamins and other essential nutrients. The resource abundance in a semi-evergreen forest changes with changing phenophases of the trees. This seasonal variation in phenology determines the presence of young leaves, mature leaves, fruits and flowers in a forest. Generally the period of resource abundance, or the flowering and fruiting season, is related to the onset of the monsoons. Winters are considered to be the lean periods when young leaves are scarce in the forest (Adhikari & Shrestha, 2011). My results revealed that the two Central Himalayn Langur groups did not entirely depend on the overall resource abundance of the forest for their diet. Instead the most preferred food items in fact, came from trees which were rare to find in the forest, in some cases only a few trees (2-3) of those species were present. The most abundant trees within the territory, like *Quercus leucotrichophora* and *Alnus nepalensis,* contributed a very small percent to the diet of these langurs. The flush leaves of moderately abundant species like *Carpinus viminea* were preferred food items in the natural forest. Likewise, the young leaves of *Prunus cerasoides* were the preferred food item in lagurs living near the farm lands. This supports my initial hypothesis that diet selection is not related to resource abundance for Central Himalayan Langurs.

Semnopithecus entellus (Brandon-Jones, 2004) foraging behaviour has been the subject of at least ten long-term studies from a minimum of five sites (Sri Lanka: Hladik, 1977, Dahwar: Yoshiba, 1957, Nepal Himalays: Curten, 1975, Kanha: Newton, 1992, Jodhpur: Srivastava, 1998). Data from these studies substantiates their reputation as generalist feeders. While these studies represent a wide range of habitats from Sri Lanka to the Himalayas, the overall contribution of primary food types differs surprisingly little; leaf parts range from 45 to 60% of the diet. Supplemental and fallback foods are more variable. Langurs include insects as a primary supplemental resource at lowland sites, but fallback foods in the Himalayas are underground storage organs and bark (Syers & Norconk, 2008).

In a recent review, (Koenig & Borries, 2001) noted a positive correlation between consumption and abundance of young leaves, flowers, and fruit in the feeding ecology of lowland gray langur populations, and suggested that they "feed on everything that is available except mature leaves." The current study also showed a positive correlation between consumption and abundance for flush leaves, unripe fruits, ripe fruits and flowers. Central Himalayan langurs broaden the feeding repertoire of gray langurs by inhabiting an environment so marginal that mature leaves are ingested whenever they are available. The ability to subsist, at least seasonally, on non-preferred foods is likely one reason for the expansive geographical and ecological range of gray langurs, including decidedly marginal habitats such as the Himalayas.

In Central Himalayan langurs in a natural forest habitat , flush leaves, fruits and flowers are clearly important seasonal foods and in farm lands, only fruits and flowers are important seasonal fruits. However, given that mature leaves and young leaves are available at different times of the year, and all were taken in relation to their abundance, it is difficult to argue for a major preference of one type over the other.

VII. MANAGEMENT RECOMMENDATIONS

The primary threat facing primates today is habitat destruction. By reducing forest size and quality, habitat destruction leads to the reduction of food sources for forest-dwelling primates and in some cases threatens them with local extinction purposes is the main threat to populations of Central Himalayan langur.

This study could serve as a management tool to increase the base of existing food resources by planting food species in the sanctuary. Conserving plants of *Carpinus viminea* the most important winter food resources and very less in number. This study also recommends that langurs in anthropogenic farm land prefer *Prunus cerasoides*. Plantation of this species periphery of the village may reduce the crop raiding by the langurs in the winter.

VIII. SUMMERY

Knowledge of a species' ranging patterns is vital for understanding its behavioural ecology and vulnerability to extinction. Given the abundance and even distribution of leaves in forested habitats, folivorous primates generally spend less time feeding more time resting and require smaller home ranges than frugivorous primates. This study aims to provide a detailed quantification of Central Himalayan Langur activity budgets, diet and food preference using direct observations on two habituated group in Kedarnath Wildlife Sanctuary, Uttarakhand India. Activity was recorded with 15-min instantaneous sampling and 15-min focal animal sampling between December 2014 and March 2005. Langur in both the habitat spent more time on resting (45-50%) and less time on moving (35-40) and feeding (40%). How animals allocate their time to various activities has significant consequences for their survival because they reflect the different constraints on time-energy balances. Many ecological variables, such as day length, temperature, food availability, are supposed to effect on activity budgets allocation of temperate primates.

Primate diets are known to change according to seasonal variations in the forest and according to changes in resource availability. The colobines are folivorous primates who have the capability of foregut fermentation using microbes in their sacculated stomachs.

The stomachs of these colobines are specially designed to digest leaves and plant material laden with secondary metabolites, high fibre content and lignin. The food selection, preference, and diet composition of Central Himalayan Langur were studied during winter season. Central Himalayan Langur spent 40% of their time in feeding during winter months. Flush leaves (31%), young leaves (19%), mature leaves (34%), unripe fruits (5%), ripe fruits (2%), flowers (5%) and root (3%) constituted the major food items. Members of Forest Troop were observed feeding on plant foods from a minimum of 19 families, 26 genera, and 35 species and member of Village Troop were observed feeding on plant foods from a minimum of 20 families, 29 genera, and 36 species. Plants in the Rosaceae family were widely consumed. Central Himalayan Langur often ate flush leaves of *Carpinus viminea* in forest habitat and young leaves of *Prunus cerasoides* in anthropogenic farm land.

The overall finding of the present study indicates that the study species i.e. the Central Himalayan Langur does not select their diet or food based on the abundance of the food or plant species.

REFERENCES

Adhikaree, A and Shrestha, T. K. 2011. Food item selection of Hanuman Langur (*Presbytes entellus*) in different session in Char- Koshe junge of Eastern Terai, Nepal. *Nepalese journal of Bioscience*, 1:96-103

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49:227-267.

Altmann, J. 1980. *Baboon mothers and infants*. Cambridge: Harvard University Press.

Bishop, N. H. 1975. *Social behavior of langur monkeys* (*Presbytis entellus*) in a high altitude environment. Ph.D. thesis, University of California at Berkeley.

Beniston, M. 2003. *Climatic change in mountain regions*: a review of possible impacts. Climatic Change. 59:5–31.

Bishop, N. H. 1978 . Langurs living at high altitudes. *Journal of the Bombay Natural History Society*, 74, 518–520.

Bishop, N. H. 1979. Himalayan langurs: Temperate Colobines. *J Hum Evol.* 8:251–281.

Brandon-Jones, D. 2004. A taxonomic revision of the langurs and leaf monkeys (Primates: Colobinae) of south Asia. *Zoo's Print Journal* 19:1552–1594.

Bronikowski, A. M., Altmann, J. 1996. Foraging in a variable environment: weather patterns and the behavioural ecology of baboons. *Behav Ecol Sociobiol.* 39:11–2

Chapman, C. A, Pavelka, M. S. M. 2005. Group size in folivorous primates: ecological constraints and the possible influence of social factors. *International Journal of Primatology* 46, 1-9.

Chivers, D. J., Hladik, C. M. 1980. Morphology of the gastrointestinal tract in primates: comparisons with other mammals in relation to diet. *J. Morphol*. 166, 377–386.

Choudhury, A. U. 2007. The eastern limit of distribution of the hanuman langur Semnopithecus entellus dufresene. *Journal of the Bombay Natural History Society,* 104, 199–200.

Champion, H. G., Seth.S. K. 1968. *A Revised Survey of the Forest Types of India.* New Delhi: Government of India Publications

Cluttion-Brock, T. S. 1974. Activity patterns of red colobus (Colobus badius tephrosceles). *Folia Primatol.*, 21: 161-187.

Cluttion-Brock, T. S. 1977. *Some aspects of intraspecific variation in feeding and ranging behaviour in primates.*In: *Primate Ecology*, T. H. Cluttion-Brock (ed.), Academic Press, London & New York, pp.539-556.

Curtin, R. A. 1975. The socioecology of the common langur, *Presbytis entellus,* in the Nepal himalaya. Ph.D. thesis, University of California at Berkeley.

Dasilva, G. L. 1994. Diet of *Colobus polykomos* on Tiwai Island: Selection of food in relation to its seasonal abundance and nutritional quality. *Int J Primatol* 15:655-80.

Defler, T. R. 1995. The time budget of a group of wild woolly monkeys (Lagothrix lagotricha). *International Journal of Primatology,* 16: 107–120.

Disotell, T.R., 2000. Molecular systematics of the Cercopithecidae. In: Whitehead, P.F., Jolly, C.J. (Eds.), Old World Monkeys. Cambridge University Press, Cambridge, pp.29–56.

Dunbar, R.I.M. 1988. *Primate social systems.* Ithaca, NY: Cornell University Press.

Dunbar, R.I.M. 1992. Time: A hidden constraint on the behavioural ecology of baboons. *Behavioural ecology and sociobiology* 31: 35-49

Dunbar, R.I.M., Korstjens, A.H and Lehmann, J. 2009. Time as an ecological constraint. *Biological Reviews*. 84:413–429.

Ellerman, J. R., & Morrison-Scott, T. C. S. 1966. Checklist of palaearctic and Indian mammals, 1758– 1946 (2nd ed.). London: Trustees of the British Museum (Natural History).

Freeland, W. J. And D.H. Janzen. 1974. Strategies of herbivory in mammals; the role of plant secondary compounds. *American Naturalist* 108: 269-289.

Ganguli, B. N., R. N. Kaul & K. T. N. Nambiar. 1964. Preliminary studies on few top feed species. *Annals of Arid Zone* 3:31-37.

Groves, C. 2001. *Primate taxonomy*. Washington, D.C.:Smithsonian Institution Pr. 350p.

Gairola, S. 2010. *Phytodiversity, forest composition, growing stock variation and regeneration status in the Mandal-Chopta forest of Garhwal Himalaya. Dissertation for the Doctor Degree. Srinagar (Garhwal), India*: HNB Garhwal University

Hill, W. C. 1939. An annotated systematic list of the leaf-monkeys. *Ceylon Journal of Science, Colombo*, 21, 277–305.

Hladik, C. 1977. *A comparative study of the feeding strategies of two sympatric species of leaf monkeys: Presbytis senex* and *Presbytis entellus*. Clutton-Brock TH, editor. In: Primate ecology. New York: Academic Press, pp. 324–353.

Huang, C and Lu, L. 1995. Strategy of white-headed langur choosing night-staying cave. *Chinese J. Zool.* 30(5): 36–37.

Isbill, L.A and Young, T. P. 1993. Social and ecologiocal influence on activity budget of vervat monkeys and their implications for group leaving . *Behav Ecol Sociobio*, 32:377-385

Kala, S. P, Gaur, R. D. 1982. *A contribution to the flora of Gopeshwar* (Chamoli- Garhwal). In: Paliwal, G. S. (ed.). The vegetation wealth of Himalayas, Puja Publishers, Delhi. pp.347-413.

Kiss, A. 1990. Living with wildlife: wildlife resource. *World Bank Technical Paper*, 130. World Bank, Washington, DC, equitable co-management partnerships between local USA.

Koenig, A and Borries, C. 2001. Socioecology of Hanuman langurs: The story of their success. *Evolutionary Anthropology* 10:122-37.

Krishnamani, R. 1994. Diet composition of the bonnet macaque (Macaca radiata) in a tropical dry evergreen forest of southern India. *Tropical Biodiversity* 2: 285-302.

Kumar, A. 1987. *The Ecology and Population Dynamics of the Lion-Tailed Macaque* (Macaca silenus) *of South India.* PhD thesis, Cambridge University.

Lechowicz, J. M. 1982. The sampling characteristics of electivity indices. **Oecologica** 52:22-30.

Marsh, C. 1981. Time budget of Tana River red colobus. *Folia Primatol* 35 : 30-50

Majumdar, B. N, S. A. Momin and D. N. Kehar. 1967. Studies on tree leaves as cattle fodder. Chemical composition as affected by locality. *Indian Journal of Veterinary Sciences* , 37:224-231.

Masi ,S. Cipolletta ,C and Robbins M. M. 2009. Western lowland gorillas (*Gorilla gorilla gorilla)* change their activity patterns in response to frugivory:*American journal of Primatology.71:91-100*

Mcwilliams, S.R., Island, R., 2002. Ecology of Vertebrate Nutrition. encyclopedia of life *sciences*

McDonald, J. H. 2014. *Handbook of Biological Statistics* (3rd ed.). Sparky House Publishing, Baltimore, USA.

Mcwilliams, S. R, Island, R. 2002. Ecology of Vertebrate Nutrition. *encyclopedia of life sciences* :823-844.

M´enard, N, Vallet, D. 1997. Behavioral responses of Barbarymacaques (*Macaca sylvanus*) to variations in environmental conditions in Algeria. *Am J Primatol* 43:285–304.

Milton, K. 1980. *The foraging strategy of howler monkeys: a study in primate economics.* Columbia University Press, New York

Moe, S. R. 1993. Mineral content and wildlife use of soil licks in south western Nepal. *Can. J. Zool.* 71(5): 933-936.

Nadler, T. Momberg , F, Nguyen Xuan Dang and Lormee, N. 2003. *Vietnam Primate Conservation Status Review* 2002: Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi

Napier, J. R., and Napier, P. H. 1967. *A handbook of living primates.* London: Academic Press.

Newton, P. 1992. Feeding and ranging patterns of forest hanuman langurs (*Presbytis entellus*). *Int J Primatol* 13:245-85.

Oates, J. F, Waterman, P. G and G.M. Choo. 1980. Food selection by the South Indian leaf monkey, Presbytis johnii in relation to leaf chemistry. *Oecologia* 45: 45- 56.

Oates, J. F, Davies, A. G and Delson, E. 1994. *The diversity of living colobines.* In A. G. Davies & J. F. Oates (Eds.), Colobine monkeys: Their ecology, behaviour and evolution (pp. 45–73). Cambridge: Cambridge University Press.

Overdorff, D. J. 1996. Ecological correlates to activity and habitat use of two prosimian primates: Eulemur rubriventer and Eulemur fulvus rufus in Madagascar. *Am J Primatol* 40:327–342

Pocock, R. I. 1928. The langurs or leaf monkeys of British India. *Journal of the Bombay Natural History Society*, 32(472–504), 660–672.

Pocock, R. I. 1939. Primates and carnivora (in part) (pp. 97–163). London: Taylor and Francis.

Post, D. 1981. Activity patterns of yellow baboons *(Papio cynocephalus)* in the Amboseli National Park, Kenya. *Anita Behav* 29 : 357-374

Prabhakar, B, Sharma, S.S, Singh, R. L. 2001. *Management plan of Kedarnath musk deer Sanctuary (from 2000-2001 to 2009-2010) Part I and II, Wildlife preservation organization,* Forest department, U.P.

Qihai Zhou. Q, Fuwen Wei, Chengming Huang, Ming Li, Ren B and Luo B. 2007. Seasonal Variation in the Activity Patterns and Time Budgets of *Trachypithecus francoisi* in the Nongang Nature Reserve, China. **Int. J. Primatol**. 28, 657-671.

Ripley, S. 1970. Leaves and Leaf-monkeys, the social organization of foraging in Gray langurs (*Presbytis entellus*). In Napier, J. R., and Napier, P. H. (eds.), *Old world monkeys evolution*

Roonwal, M. L. And S.M. Mohnot. 1977. Hanuman Langur. In: *Primates of South Asia Ecology, Sociobiology and Behaviour* (Eds. M.L. Roonwall & S.M. Mohnot). Harvard University Press. Chicago.

Roonwal M. L. 1979. Field observations on the distribution and tail carriage in the central Himalayan langur, *Presbytis entellus schistaceus* (Primates). *Proc India Natl Sci Acad* B45(1):45-55.

Roonwal, M. L. 1984. Tail form and carriage in Asian and other primates, and their behavioral and evolutionary significance. In M. L. Roonwal, S. M. Mohnot, and N. S. Rathore, (Eds.), *Current primate research* (pp. 93–151). Jodhpur, India: Jodhpur University Press.

Ruiter, J .D. 1986. The influence of group size on predator scanning and foraging behaviour of wedge-capped capuchin monkeysn *(Cebus olivaceus). Behaviour* 98 : 240-258

Sharma, C. M, Suyal, S, Gairola, S, Ghildiyal, S. K. 2009. Species richness and diversity along an altitudinal gradient in moist temperate forest of Garhwal Himalaya. *The Journal of American Science* , 5(5):119-128.

Singh, S. P. 2007. *Climate change an overview.* In: Selvasekarapandian, S., Pandit, G.G., Ramachandran, T.V. (edts.). Fifteenth national symposium on environment (NSE- 15). Mitigation of pollutants for clean environment BARC Macmillan India Ltd. Mumbai.

Smith, C. C. 1977. *Feeding behaviour and social organization in howling monkeys. In: Primate Ecology*, T. H. Cluttion-Brock (Ed.), Academic Press, London & New York, pp. 97 126.

Struhsaker, T.T. 1975. The red colobus monkey. University of Chicago Press, Chicago

Seyfarth, R. M . 1980. The distribution of grooming and relatedbehaviours among adult female vervet monkeys. Anim Behav 28 : 798-813

Sayers. K, Norconk, M.A. 2008. Himalayan Semnopithecus entellus at Langtang. National Park, Nepal: Diet, Activity Patterns, and Resources. *Int J Primaltol.* 29:509–530.

Schoener, T.W. 1971. Theory of feeding strategies. *Ann. Rev. Ecol. Syst.* 2: 369–404.

Singh, M and Vinathe, S. 1990. Inter-population differences in the time budgets of bonnet monkeys (*Macaca radiata*). *Primates* 31:589 -596

Srivastava, A. 1989. *Feeding ecology and behaviour of Hanuman langur, Presbytis entellus*. Ph.D. thesis, University of Jodhpur, India.

Struhsaker, T.T. 1975. *The Red Colobus Monkey*. Chicago University Press, Chicago.

Stelzner, J. K. 1988. Thermal effects on movement patterns of yellow baboons. *Primates.* 29:91–105

Stanford, C. B.1991. The capped langur in Bangladesh: Behavioral ecology and reproductive tactics. New York: Karger.

Stephens, D. W. and Krebs, J. R. 1986. *Foraging Theory. Princeton University Press,* Princeton, New Jersey

Tejwani, K.G. 1994. Agro Forestry in India. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Terborgh, J. 1983. *Five new world primates: a study in comparative ecology*. Princeton University Press, Princeton, New Jersey

Vogel, C. 1971. *Behavioral differences for Presbytis entellus in two different habitats.* Proceedings of Third International Congress of Primatology, *Zurich.* 1970/3: 41- 47.

Walters, J. R, Seyfarth R. M. 1987. *Conflict and cooperation*. In: Smuts, B. B, Cheney, D.L, Seyfarth RM, Wrangham RW, Struhsakern TT (Eds) Primate societies. University of Chicago Press, Chicago, pp 306-317

Waster, P. 1977. Feeding, ranging and group size in the mangabey Cercocebus albigena. In: Primate Ecology, T. H. Cluttion-Brock (ed.), Academic Press, London & New York, pp. 183-222.

Watts, D. 1988. Environmental influences on mountain gorilla time budgets. *Am J Primatol* 15:195-211

Western, D, Wright, R. M. and Strum, S.C. (Eds), 1994. *Natural Connections: Perspectives in Community-based Conservation.* Island Press, Washington, DC, USA.

Yoshiba, K. 1967. An ecological study of Hanuman langurs, *Presbytis entellus.* Primates 8:127-54.

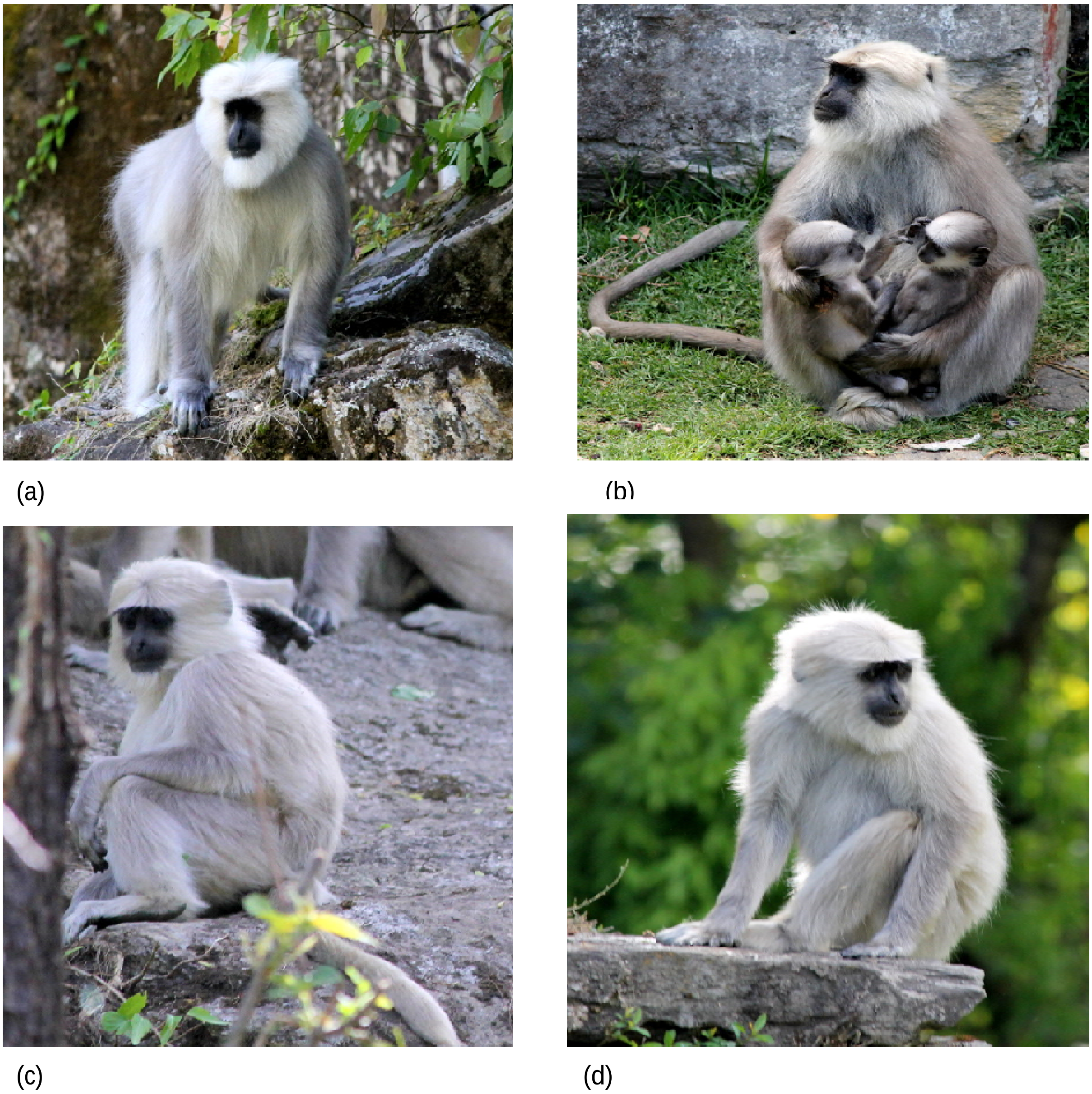


Plate.1 *Semnopithecus schistaceus* adult male (a), adult female (b), juvenile (c), sub adult (d).

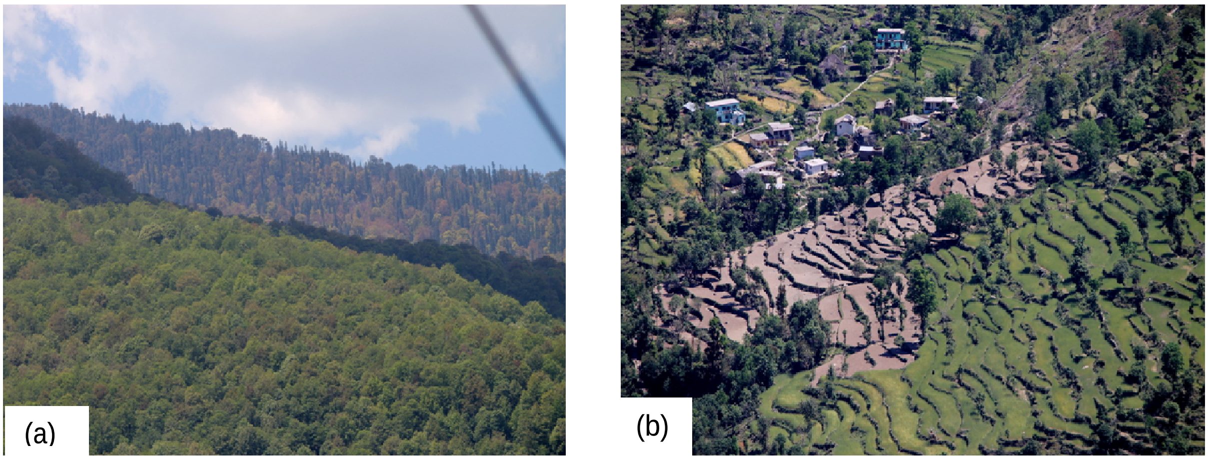


Plate.2 : Habitats-Natural forest (a), antropogenic farmland (b).Photo credit Himani Nautiyal

(a)

(b)

(c)

(d)

Plate 2: Activities performed by *Semnopithecus schistaceus*, feeding on agricultural crops (a), feeding on *Albizia spp* (b), allogrooming (c), sleeping (d). Photo credit Himani Nautiyal